Lionfish Control in Belize: The Potential for Regional Replication

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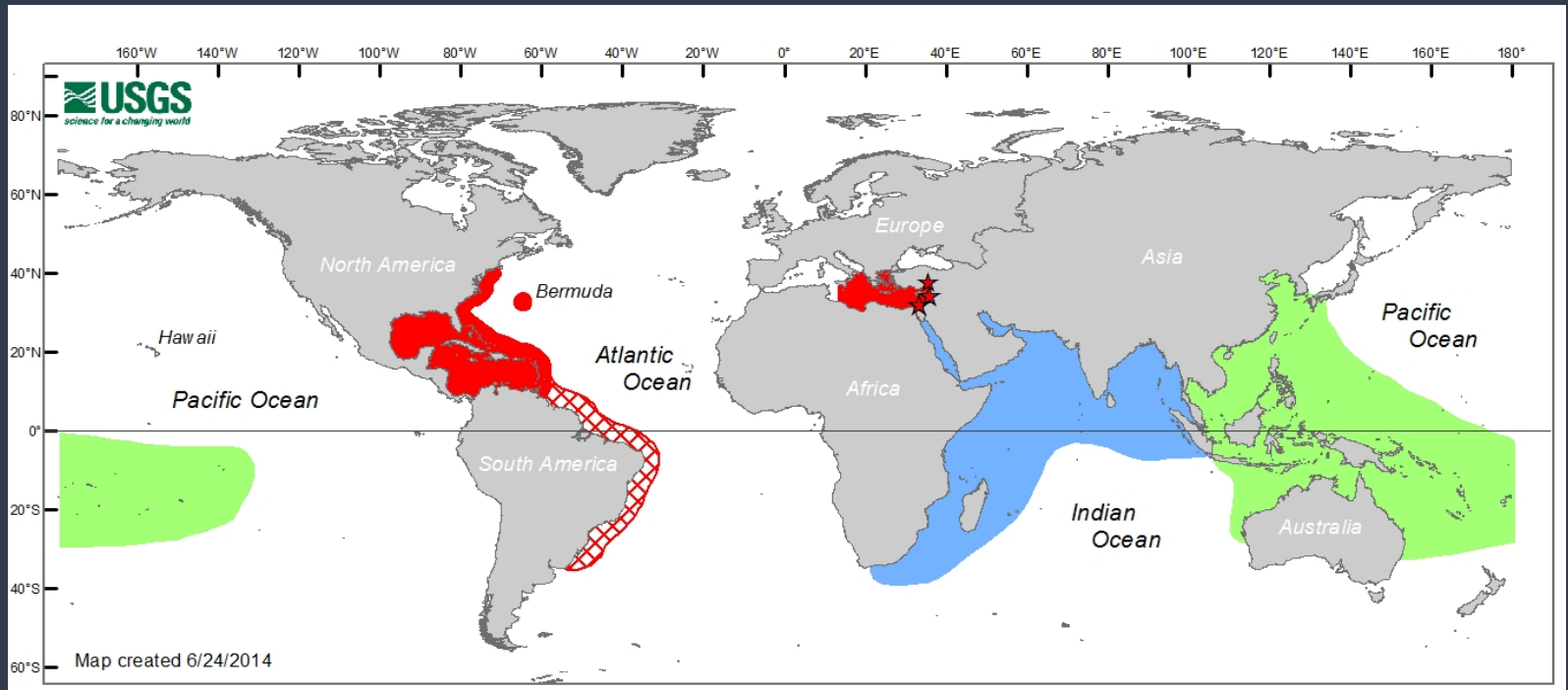
Belize Marine Fund Webinar - August 18, 2022

Background



Map of native range of *Pterois volitans* (green) and *P. miles* (blue) adapted from Schultz (1986) and Randall (2005). Stars in Mediterranean Sea denote Lessepsian migration of *P. miles* via the Suez Canal (Golani and Sonin 1992; Bariche et al. 2013; Turan et al. 2014). Non-native range of *P. volitans* and *P. miles* in the Americas is shown in red (from Schofield et al. 2012). Predicted future distribution of lionfish along coastal South America is shown in red hatching (Morris and Whitfield 2009). Lionfish are continuing to expand westward in the Mediterranean Sea (red shading). See Azzurro et al. (2017) for a review.

Characteristics of a successful invader

- No natural predators
- Fast growth
- Reproduce every 3-4 days (2 million eggs/year)
- Ecological generalist (0 > 300m depth)
- Skillful hunters (jet stream, corner prey)
- High food availability (reefs has high biodiversity)
- Unrecognized by native prey species

Lionfish grow and mature faster than most WA mesopredators

Species	Common name	Method	Fecundity	Minimum age at maturity	Growth rate k (cm per year)
Pterois volitans (introduced range)	Red lionfish	3	PE: 10,790–41,392[1] A: 2,000,000[1] (25.0–35.0 TL)	<1 year[1]	0.47[9]
Lutjanus analis	Mutton snapper	?	PE/A: 373,000–1,370,000[8] (46–55 cm TL; Bahamas)	2 years[6]	0.13–0.25[5]
Lutjanus apodus	Schoolmaster	–	–	–	0.35[5]
Lutjanus griseus	Grey snapper	–	–	–	0.10–0.24[5]
Lutjanus jocu	Dog snapper	–	–	–	0.10[5]
Lutjanus mahogoni	Mahogany snapper	–	–	–	0.10[5]
Cephalopholis fulva	Coney grouper	1	PE/A?: 67,883–282,389[2] (23.2–24.3 TL; Jamaica)	1.1 year[6]	0.14–0.63[5]
Epinephelus adscensionis	Rock hind	–	–	–	0.11–0.17[5]
Epinephelus guttatus	Red hind	1	PE/A: 96,000–526,000[2] (26.0–41.0 TL; Jamaica)	2 years[7]	0.12–0.24[5]
		2	PE/A: 978,620 (mean)[10] (mean: 36.7 TL; US Virgin Islands)		
Epinephelus striatus	Nassau grouper	1	PE/A: 350,000–6,500,000[3] (30.0–70.0 SL; Belize)	4 years[3]	0.06–0.22[5]
		1	PE/A: 11,724 – 4,327,440[3] (47.5–68.6 SL; Bahamas)		
Mycteroperca tigris	Tiger grouper	1	PE/A:308,060–1,972,434[4] (25.5–37.5 SL; Puerto Rico)	2 years[4]	0.11[5]

(Côté, Green & Hixon, 2013)

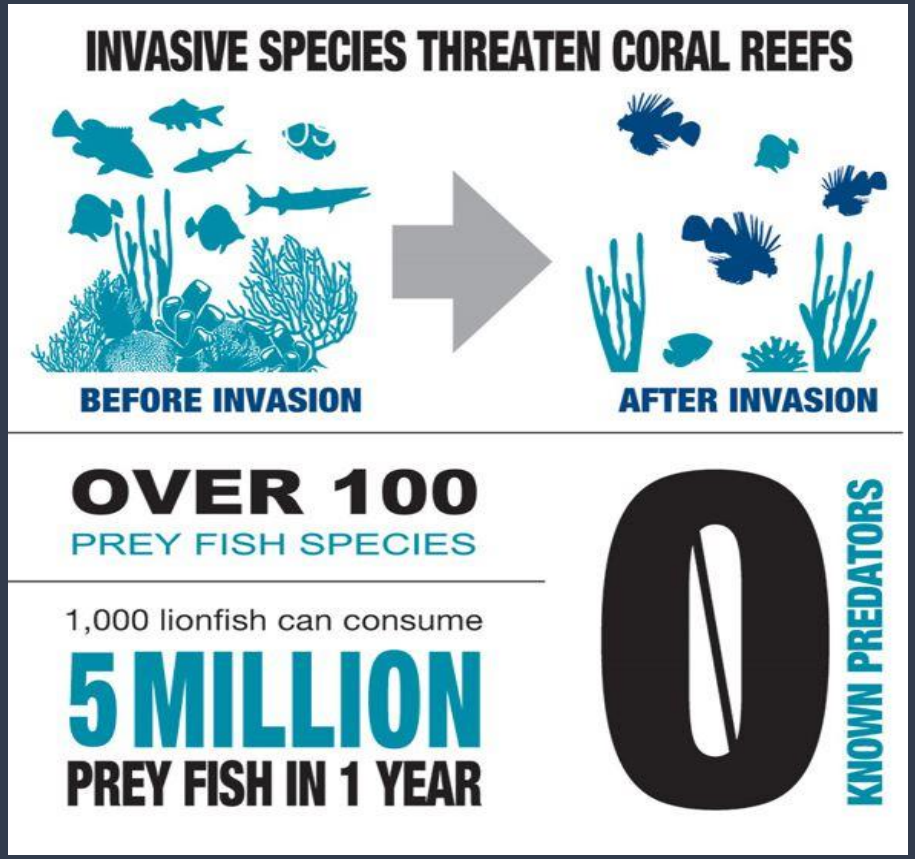
Complete eradication unlikely

(Morris & Whitfield, 2009)

~~Eradication~~

Control

Significant ecological Impacts



“The most significant change to coral reefs since industrial fishing”

Some fish are impacted more than others

- *Small, shallow-bodied, solitary* fishes - ***most vulnerable***
- Fishes that show *cleaning behaviour* - **lower risk**

TRAIT	MORE VULNERABLE	LESS VULNERABLE
Size	Small, e.g. greenblotch parrotfish	Large, e.g. graysby
Shape	Shallow-bodied, e.g. clown wrasse	Deep bodied, e.g. butterflyfish
Aggregation size	Solitary, e.g. Spanish hogfish	Schooling, e.g. French grunt
Water column position	Benthic fishes, e.g. masked goby	Pelagic fishes, e.g. bar jack
Nocturnally active	Yes, e.g. squirrelfish	No, e.g. striped parrotfish
Cleaning behaviour	No, e.g. French angelfish	Yes, e.g. neon goby

Important consequences for endemic species

Social Wrasse (Halichoeres Socialis)

A single lionfish can consume dozens of juvenile social wrasses every day

Lionfish are pushing this critically endangered specie closer to extinction

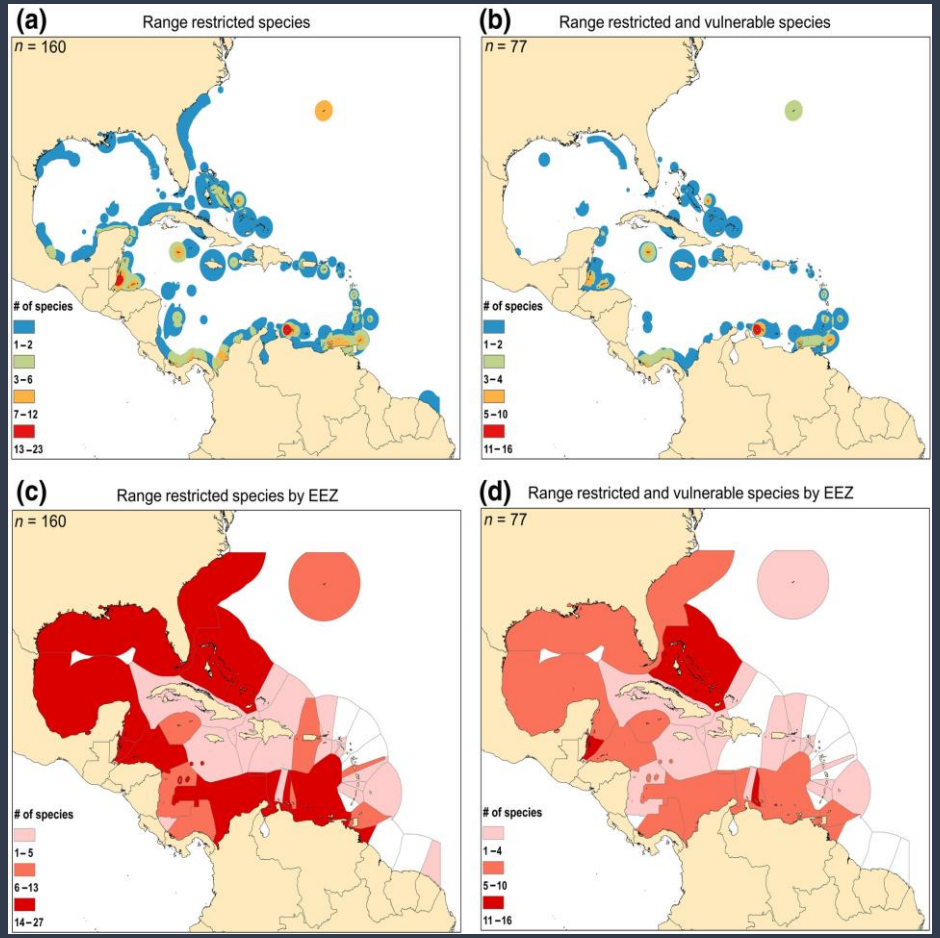
Why are they important?

They feed on plankton that comes from the open ocean, which serves as a nutrient source for the reef itself, transferring resources from the open ocean to the reef

Removing them can have severe impacts on the local ecosystem's health

Belize is a hotspot of potential impact

- **Bahamas**, **Belize** and **Curaçao** identified as vulnerability hotspots - 77 fishes with small ranges identified at risk



National Lionfish Management Strategy and working group (2019-2023)

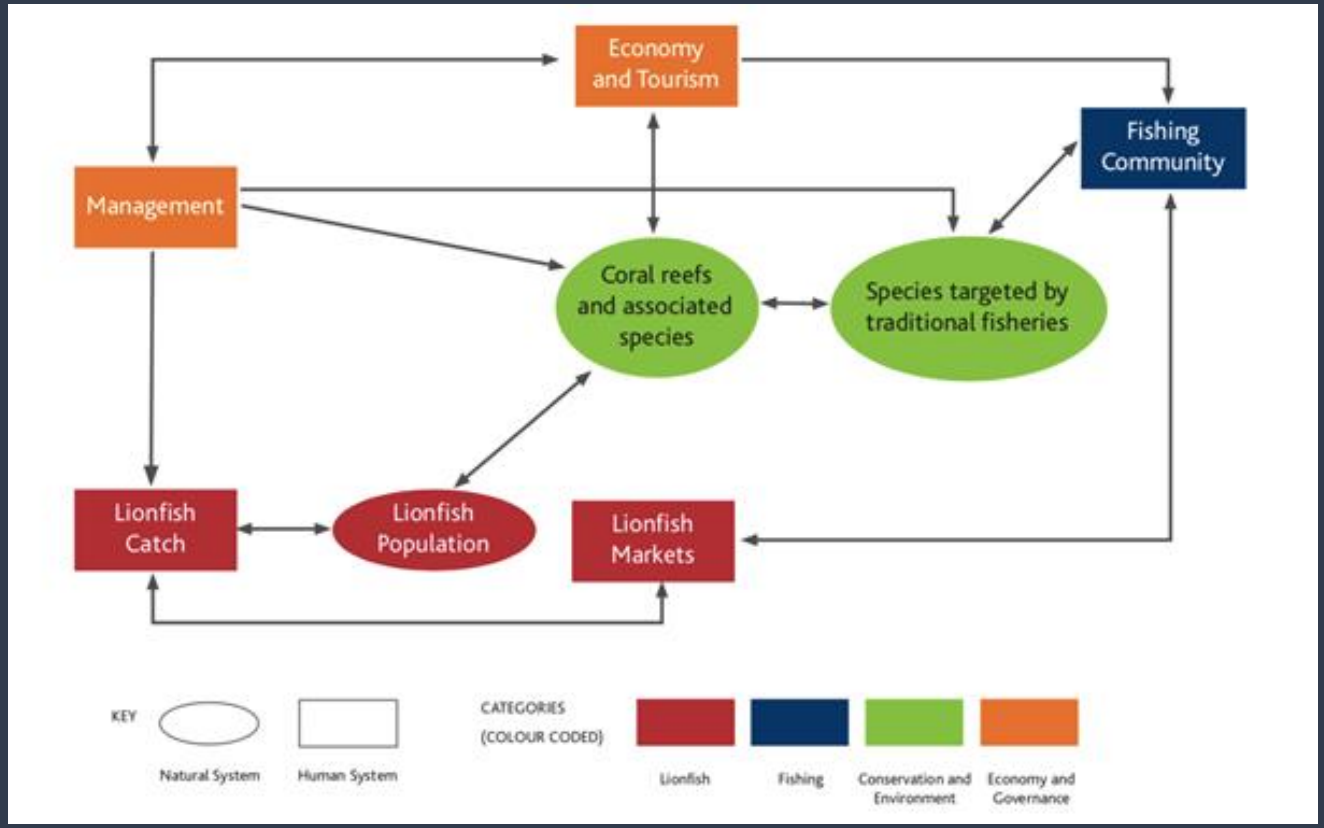
Vision

Adaptively managing lionfish in a participatory manner, to protect an improve livelihoods of all Belizeans and the health of Belize's marine environment.

Key objective

A key objective of this strategy is to develop a long-term community-le monitoring program, responsible for guiding effective lionfish management, monitoring and evaluation efforts across Belize.

Recognising the interconnectedness of the system



*2015 national priority assessment

PA, Management Entity & Managed Access area	Justification	Priority Level (*low, med, high*)
Southwater Caye Marine Reserve (SWCMR), Belize Fisheries Department: Managed Access Area 3	Based on 2015 survey results, had highest lionfish density.	*high*
Sapodilla Cayes Marine Reserve (SCMR), Belize Fisheries Department: Managed Access Area 4	Based on 2017 observations there were a lot of lionfish, but in 2019 sightings were low; gaps in knowledge exist for monitoring; little diving activity for Sap Cayes and this could mean little is an indication for increased presence of lionfish control is occurring	*high*
Caye Caulker Marine Reserve (CCMR), Belize Fisheries Department: Managed Access Area 1	Need more lionfish control in certain areas; 2015 surveys showed areas exist with high and low lionfish counts	*high*
Bacalar Chico Marine Reserve (BCMR), Belize Fisheries Department: Managed Access Area 1	Need higher level of control of lionfish removal	high
Turneffe Atoll Marine Reserve (TAMR), Turneffe Atoll Sustainability Association: Managed Access Area 6	An existing gap, previous studies have indicated high numbers; possibility that no-take-zones have high numbers of lionfish; general-use-zones also need to be surveyed for comparison	high
Gladden Spit & Silk Cayes Marine Reserve, Southern Environmental Association: Managed Access Area 3	Juvenile sightings are high especially in whale shark zone (phase I & III); 2014 baseline data exists with SEA and BV	high

2020+

Establishing effective lionfish management in Belize's fish replenishment zones

Support Belize MPA managers to establish a scalable model for effective and participatory lionfish adaptive management

Focus: capacity building, involving key stakeholders, & piloting an approach that can be replicated throughout the LAC region

BELIZE FISHERIES DEPARTMENT

MAR FUND

NEW ENGLAND BioLabs Inc.

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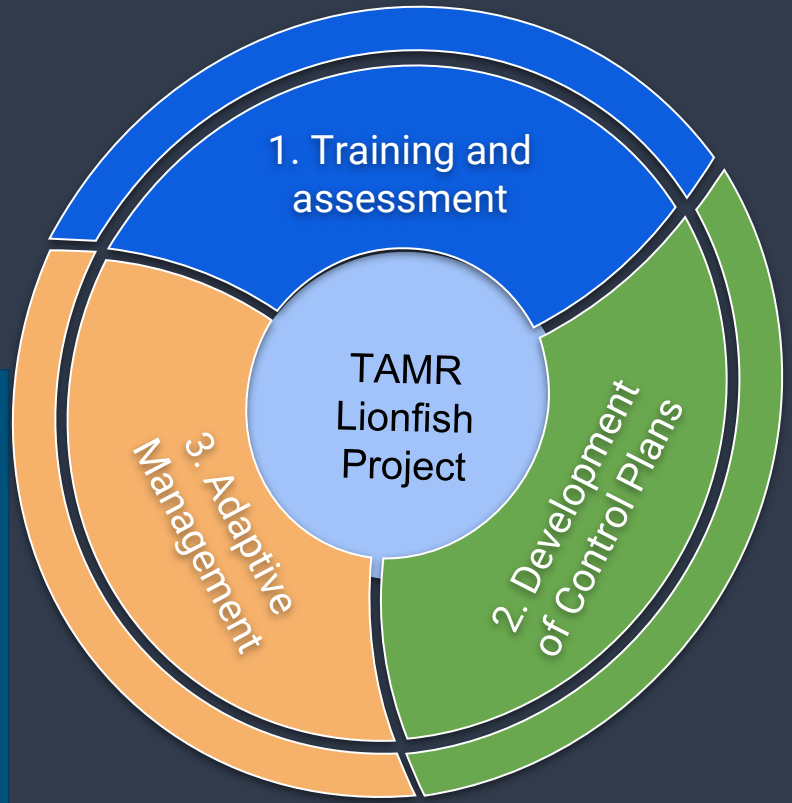
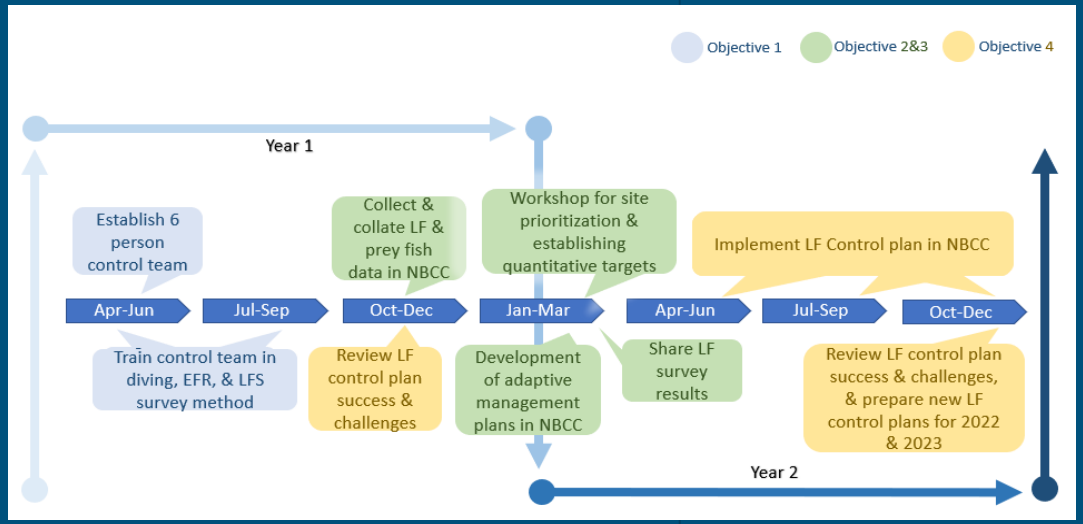
Project components & activities





Training & capacity building

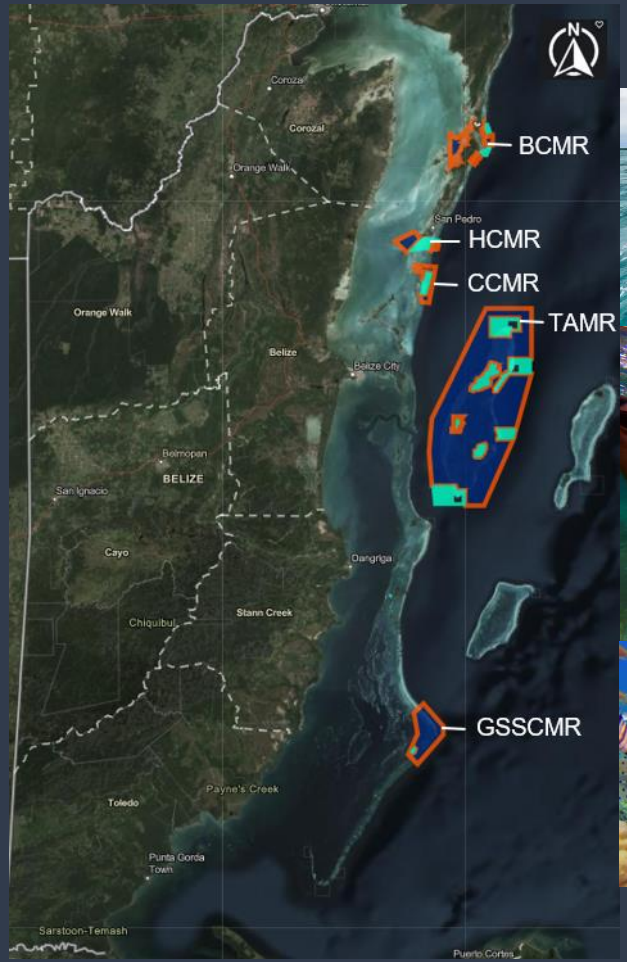
Since 2020, BV has trained 18 MPA staff and partners in:

- Lionfish Focused Search (LFS) survey methods
- Principles of lionfish monitoring and adaptive management
- Fish ID training
- PADI scuba certification
- Emergency First Response & First Aid

Assessment

Updated population status surveys (LFS method) in 4 MPAs

- BCMR
- CCMR
- HCMR
- TAMR
- SWCMR (planned 2022)



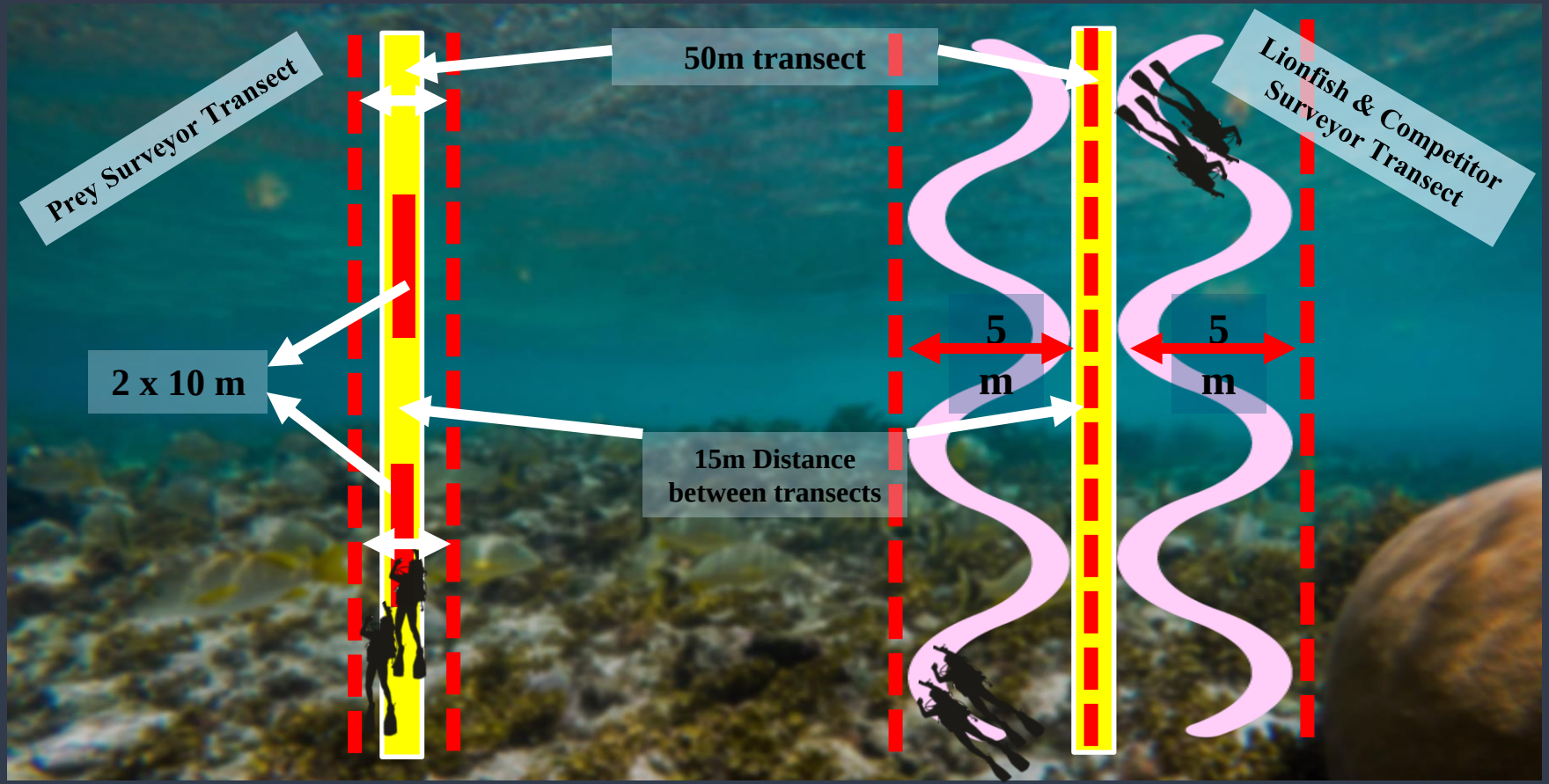
Survey method

- All data collected using **LFS Method** - *regional protocol for monitoring lionfish & impacts for complex reef systems*
- All surveyors trained and certified in LFS and Fish ID

- 3 components:

1). >30cm fish (50m x 1m transect)
2). Roving diver survey for lionfish and competitor species (50m X 10m)
3). Prey surveys (2m x 20m)

LFS method (Green et al., 2012)



Lionfish and competitor surveys

Name:_____ Date:_____ Time:_____ Site:_____ Transect:_____

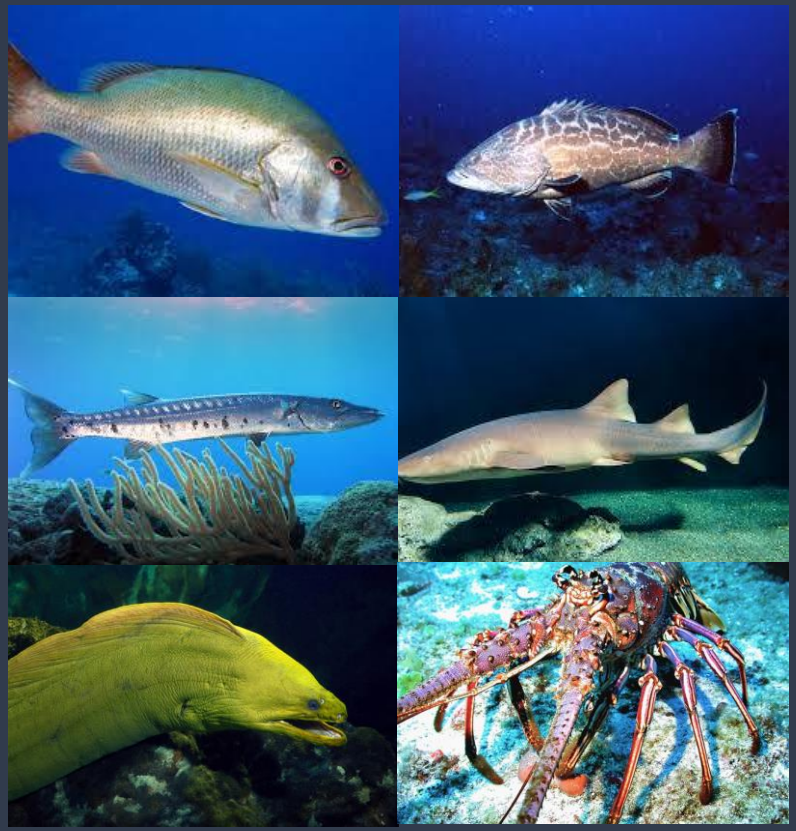
Depth: _____ (ft/m) % Cloud Cover:_____ Visibility:_____ (ft/m) **Current:** None / Mod (<1kt) / Heavy (>1kt)

H2O Temp:_____(C/F) Start Time:_____ End Time:_____

Lionfish #	Tranect Distance (m)	Size TL (cm)	Habitat (Sand, Reef, Sponge, Seagrass)	Visibility	Behaviour notes	Time sighted	Tally attempts	Time captured/ conceeded	Capture? (Y/N)	Gear type	Notes
1				EXP / SH	RST HOV SWIM HUNT						
2				EXP / SH	RST HOV SWIM HUNT						
3				EXP / SH	RST HOV SWIM HUNT						
4				EXP / SH	RST HOV SWIM HUNT						
5				EXP / SH	RST HOV SWIM HUNT						
6				EXP / SH	RST HOV SWIM HUNT						
7				EXP / SH	RST HOV SWIM HUNT						
8				EXP / SH	RST HOV SWIM HUNT						
9				EXP / SH	RST HOV SWIM HUNT						
10				EXP / SH	RST HOV SWIM HUNT						
11				EXP / SH	RST HOV SWIM HUNT						
12				EXP / SH	RST HOV SWIM HUNT						
13				EXP / SH	RST HOV SWIM HUNT						
14				EXP / SH	RST HOV SWIM HUNT						

Grouper and Lobster

#	Species	Transect distance (m)	Size TL (cm)	Habitat (Sand, Reef, Sponge, Seagrass)	Visibility	Behaviour notes
1					EXP / SH	RST HOV SWIM HUNT
2					EXP / SH	RST HOV SWIM HUNT
3					EXP / SH	RST HOV SWIM HUNT
4					EXP / SH	RST HOV SWIM HUNT
5					EXP / SH	RST HOV SWIM HUNT
6					EXP / SH	RST HOV SWIM HUNT
7					EXP / SH	RST HOV SWIM HUNT
8					EXP / SH	RST HOV SWIM HUNT
9					EXP / SH	RST HOV SWIM HUNT
10					EXP / SH	RST HOV SWIM HUNT
11					EXP / SH	RST HOV SWIM HUNT
12					EXP / SH	RST HOV SWIM HUNT



Prey surveys

Site:	Date (DD/MM/YY):	Surveyor :
T. length (m):	T. width (m):	Depth (m):
Visibility (m):	Time (HRS):	Temp (C):
Habitat (choose one): [continuous, patch]	T. Orientation (choose one from each bracket): [deep, inshore, offshore] [N, S, E, W]	

DAMSELFISH		GOBY		WRASSE	
Beaugregory		Bridled		Bluehead	
Bicolor		Cleaning		Clown	
Blue chromis		Colon		Creole	
Brown chromis		Goldspot		Slippery Dick	
Dusky		Masked		Rainbow	
Longfin		Neon		Yellowhead	
Seargent Mgr		BLENNIES		Puddingwife	
Threespot		Diamond		BUTTERFLYFISH	
Yellowtail		Redlip		banded	
Cocoa		Rosy		foureye	
HAMLET		Roughhead		longsnout	
Barred		Saddled		spotfin	
Indigo		Tube spp.		SEABASS	
Hamlet sp.		SQUIRRELFISH		black grouper	
JACK		longspine		nassau grouper	
bar		dusky		red grouper	
blue runner		Squirrelfish sp.		gag grouper	
permit		SNAPPER		graysby	
GOATFISH		grey		harlequin	
spotted		mahogany		red hind	
yellow		mutton		rock hind	
GRUNT		schoolmaster		ANGELFISH	
bluestriped		yellowtail		french	
french		lane		gray	
tomtate		dog		queen	
white		PARROTFISH		rock beauty	
porkfish		Greenblotch		OTHER	
white margate		Midnight		fairy basslet	
black margate		Princess		trumpetfish	
TRIGGERFISH		Queen		smooth trunkfish	
queen		Rainbow		yellow stingray	
ocean		Redband		sharpnose puffer	
SURGEONFISH		Redtail		atlantic spadefish	
blue tang		Stoplight		spotted drumfish	
doctorfish		Striped			
ocean		Yellowtail			

Key questions?

- How many lionfish to remove?
- How much effort is required?
- Which areas should be prioritized?

Suppression in high priority areas

Juvenile fish habitat

Marine Protected Areas

Suppression in high priority areas

Juvenile fish habitat

Marine Protected Areas

The goal:

Make the most effective use of limited resources

How many lionfish can a reef tolerate?

$$\bar{d}_x = \frac{\frac{1}{z}\sum_{\forall_z}\sum_{\forall_i}\sum_{\forall_v}\left(\frac{jW_{v,i,z}{}^{q}}{e^{\frac{E}{kT}}}\right)W_{v,i,z}}{\overline{W}_x\bar{p}(ge^{0.16T}\overline{W}_x{}^{c})y}$$

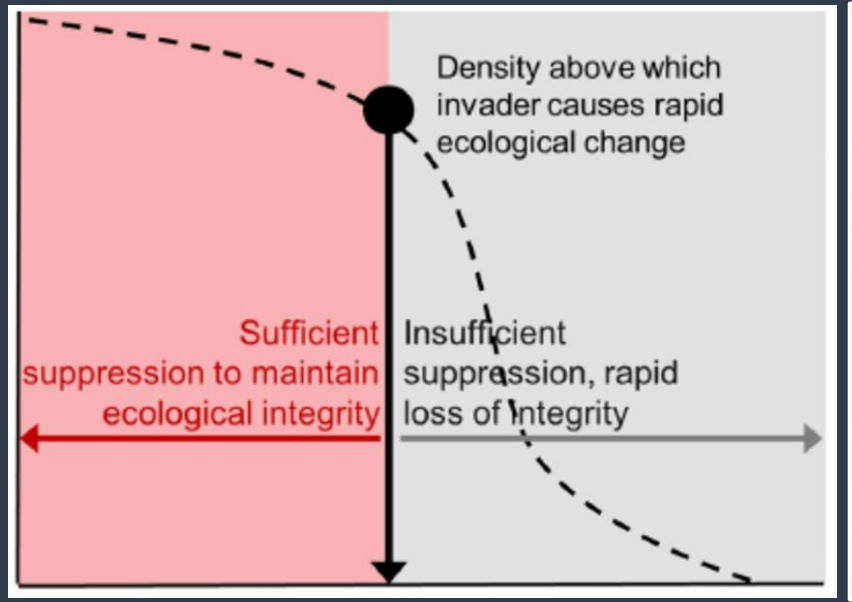
Surveys of fish biomass

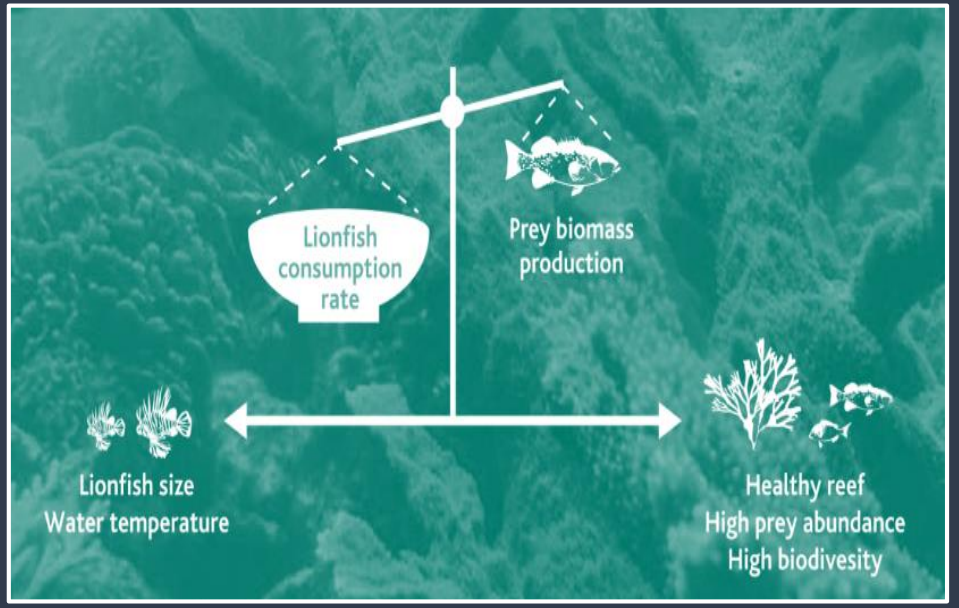
Predation rates

Lionfish densities and body sizes

(Green et al. 2014)

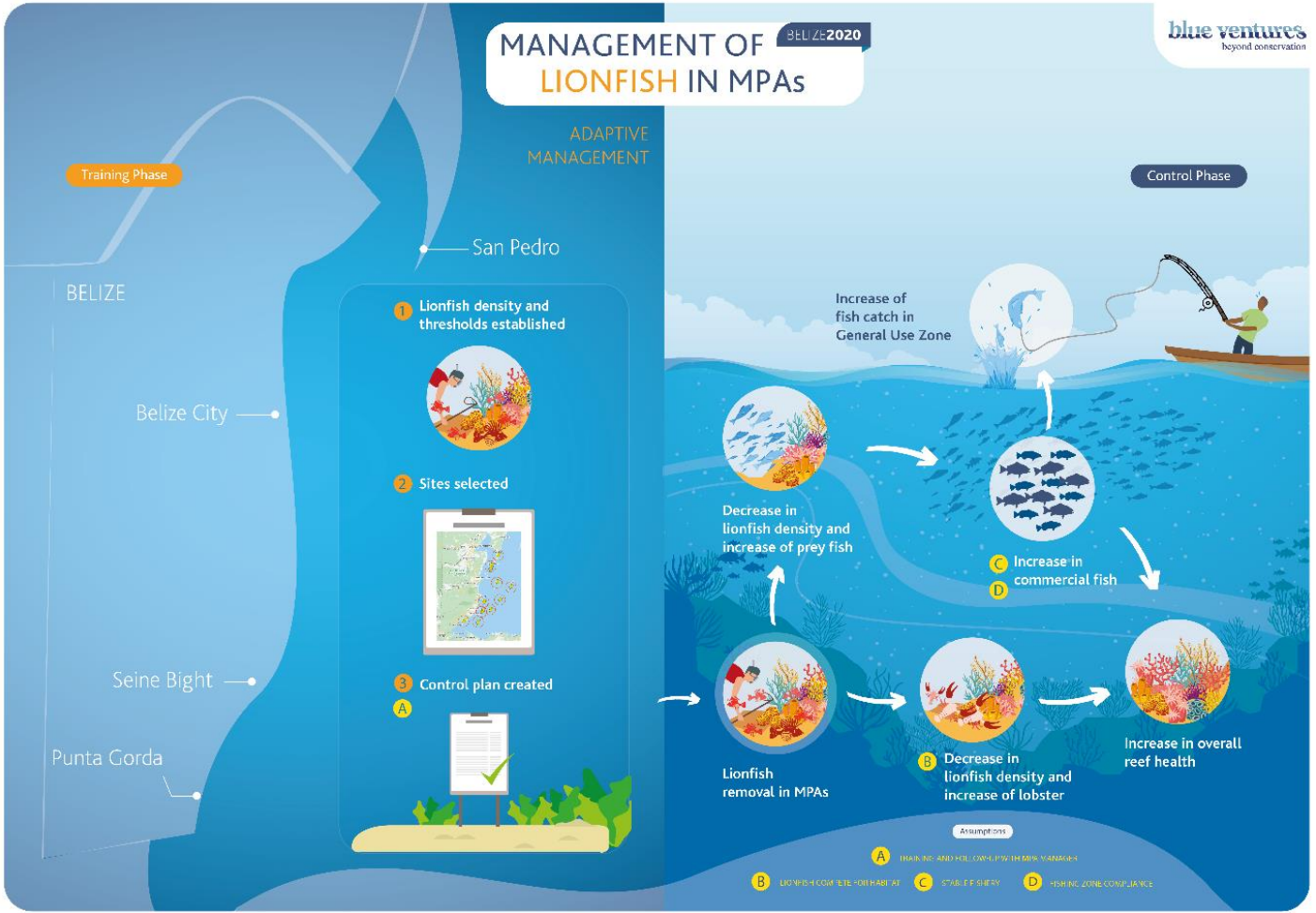
Using Limits of Acceptable Change





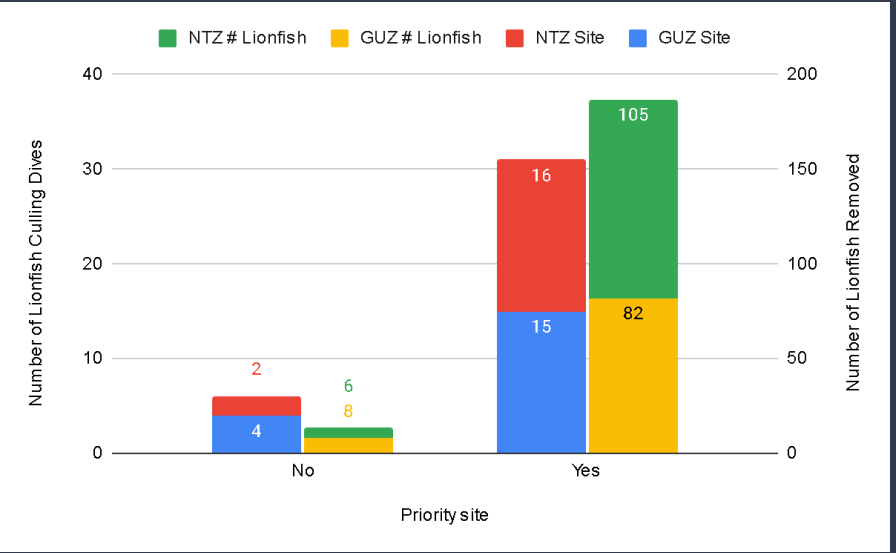
Green et al. (2014) Linking removal targets to the ecological effects of invaders: a predictive model and field test. Ecological Applications 24(6):1311-1322

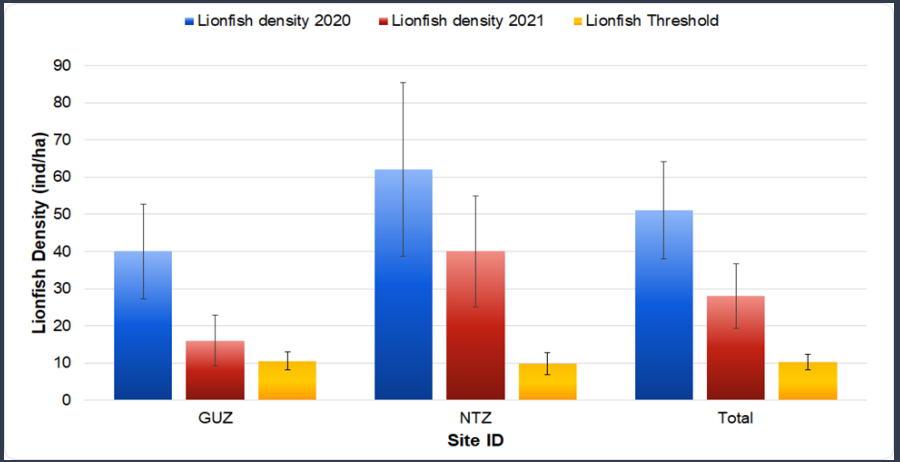
Established control plans with quantitative targets


MANAGEMENT OF LIONFISH IN MPAs
BELIZE2020
blue ventures
beyond conservation
ADAPTIVE MANAGEMENT
Training Phase
Control Phase
San Pedro
BELIZE
Belize City
Seine Bight
Punta Gorda
1 Lionfish density and thresholds established
2 Sites selected
3 Control plan created
A
Increase of fish catch in General Use Zone
Decrease in lionfish density and increase of prey fish
C Increase in
D commercial fish
Lionfish removal in MPAs
B Decrease in lionfish density and increase of lobster
Increase in overall reef health
Assumptions
A TRAINING AND FOLLOW-UP WITH MPA MANAGERS
B LIONFISH COMPETE FOR HABITAT
C STABLE FISHERY
D FISHING ZONE COMPLIANCE

Adaptive management: Turneffe Atoll

Indicators	2020	2021	Change
Average Total Length (cm)	22	21	↓
Lionfish density (ind./ha)	77	46	↓
Threshold density (ind./ha)	24	12	↓
% sites exceeding threshold	46	38	↓





Lessons learned

- adapt to suit needs of MPA
- participatory & community-led
- more emphasis on data sharing & feedback with communities
- LFS method resource intensive/expensive

Lessons learned

****New inclusive and participatory lionfish removal policy**** – Approved by the Belize Fisheries Department, August 2022

Target - LF control in 25% Belize's nearshore by 2024

frontiers

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

Aylin Ulman[1*], Fadilah Z. Ali[2], Holden E. Harris[3], Mohammad Adel[4], Sara A. Al Mabruk[5], Michel Bariche[6], Allison C. Candelmo[7], Jennifer K. Chapman[8], Burak A. Çiçek[9], Kaylin R. Clements[10], Alexander O. Fogg[11], Stacy Frank[12], Stephen R. Gittings[13], Stephanie J. Green[14], Jason M. Hall-Spencer[15], Jim Hart[16], Summer Huber[7], Philip E. Karp[17], Fabian C. Kyne[4], Demetris Kletou[18], Lauryn Magno[7], Shevy B. Rothman[19], Jennifer N. Solomon[13], Nir Stern[20], Taner Yildiz[21]

[1]Mersea Marine Consulting, Turkey, [2]Gulf and Caribbean Fisheries Institute, United States, [3]Institute for Sustainable Food Systems, Institute of Food and Agricultural Sciences, University of Florida, United States, [4]Unaffiliated, Egypt, [5]Higher Institute of Science and Technology, Libya, [6]American University of Beirut, Lebanon, [7]Reef Environmental Education Foundation, United States, [8]Blue Ventures, Belize, [9]Eastern Mediterranean University, Turkey, [10]Colorado State University, United States, [11]Okaloosa County Board of County Commissioners, United States, [12]Lionfish University, United States, [13]National Ocean Service (NOAA), United States, [14]University of Alberta, Canada, [15]University of Plymouth, United Kingdom, [16]Lionfish University, United States, [17]Unaffiliated, United States, [18]Marine and Environmental Research Lab (MER), Cyprus, [19]The Steinhardt Museum of Natural History, Tel-Aviv University, Israel, [20]National Institute of Oceanography, Israel Oceanographic and Limnological Research, Israel, [21]Faculty of Aquatic Sciences, Istanbul University, Turkey

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Thank you!

Turneffe Atoll
Sustainability Association

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beyond conservation

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Data sharing and feedback

- https://public.tableau.com/app/profile/galento.galvez/viz/LionfishSummaryDashboard/LionfishControlBelize

- https://public.tableau.com/app/profile/alexander.navarro/viz/NBCCTableau2022/Story1?publish=yes