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# An analysis of SCUBA Lionfish Hunter Specialty courses on the Dutch Caribbean island of Bonaire

*How does the involvement of the scuba dive tourism industry support the conservation objectives of the Bonaire National Marine Park?*


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WAGENINGEN UNIVERSITY & RESEARCH

Environmental Policy Group WAGENINGEN UNIVERSITY

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Wageningen University and Research
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*Disclaimer:*
*In this report all photographs and illustrations are either taken by or made by myself, or I pose in them, unless stated otherwise.*

*This report is the product of a MSc thesis as part of the Master program of Tourism, Society and Environment. It is not an official publication and does not represent any position or stance of the Wageningen University and Research.*

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Lastly, I want to thank my friends and family for always motivating me. For you have taught me that although we cannot control the current and tide where life will take us, we *can* change our mind-set and perceptions, as we put both of our hands on the wheel and try to navigate to the best of our abilities.

## Executive Summary

Within scientific literature, many have expressed the potential of invasive lionfish (*Pterois volitans* and *Pterois miles*) to ecologically harm marine ecosystems. Ever since the invasive lionfish was introduced to the Atlantic Ocean and into the Caribbean Sea, it continues to spread out, now reaching the waters surrounding Brazil and beyond. As the introduction of the invasive species into these waters is a relatively new problem, so are the management strategies aimed to combat this problem. It is therefore important to undertake analyses as time goes on and this dynamic changes. In the case of Bonaire, the PADI Distinctive Lionfish Hunter Specialty course was created to generate more volunteers for the purpose of including tourists to become part of Stichting Nationale Parken (STINAPA) Bonaire's lionfish management and control strategy. This thesis sought to investigate the nature of engaging in a Lionfish Hunter Specialty course and its intended and unintended consequences in relation to the conservational objectives of the Bonaire National Marine Park (BNMP).

Using a practice-based approach, this thesis demonstrated how engaging in a Lionfish Hunter Specialty course is carried out, and how it evolves over space and time. Using qualitative research techniques that included desk research, field observations and nineteen semi-structured in-depth interviews, an attempt was made to map out the social practice. Zooming-in on the practice provided further detailed descriptions on the enabling factors that support it, and via the zooming-out technique, I was led to further describe the practice-arrangement bundles, which displayed how the practice is embedded in a global network of interconnected practices. Deeper analyses concerning these global interconnected practices have been omitted for they go beyond the scope of this research.

Based on the results, it is concluded that engagement in the specialty course did generate an increase in volunteers, with the vast majority of participants involving tourists. One goal of STINAPA was to increase volunteers to assist in overfishing the lionfish to control lionfish density. Further, engagement in the practice involved the dive centres that generated profit to local dive instructors. Moreover, a consumption campaign was launched that created a high demand for lionfish fillet in restaurants, resulting in further profits for divers and restaurants.

According to respondents the majority of the lionfish catches are attributed to the resident lionfish hunters opposed to the tourists. The added value of including tourists in the lionfish management and control plan is mainly for commercial reasons, education and raising awareness. The two most frequently mentioned downsides of engagement in the specialty course, are firstly inadequate use of the modified speargun (called the ELF, or ''Eliminate Lionfish'' tool) as well as inexperienced divers hanging on to coral reef, structures, or lying on the seabed, resulting in reef damage. And second, failing to successfully target the lionfish by which it adapts its behaviour and becomes wary of divers.

This thesis serves as a case study that adds to the literature on marine protected area (MPA) management and, in particular, marine invasive species management involving the scuba dive tourism industry. Keeping in mind that the results of this thesis are constricted to the specific context of Bonaire in space and time, thus any practical implications point towards a continuation of future research on the matter.

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## List of Abbreviations

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| BNMP | Bonaire National Marine Park |
| BSAC | British Sub-Aqua Club |
| CBS | Centraal Bureau voor de Statistiek (Central Bureau for Statistics) |
| CURO | Council of Underwater Resort Operators |
| ELF | Eliminate Lionfish |
| MPA | Marine Protected Area |
| NAUI | National Association of Underwater Instructors |
| NGO | Non-governmental Organisation |
| PADI | Professional Association of Diving Instructors |
| PTSD | Post-traumatic Stress Disorder |
| SCUBA | Self-Contained Underwater Breathing Apparatus |
| SDI | Scuba Diving International |
| SPT | Social Practice Theory |
| SSI | Scuba Schools International |
| STINAPA | Stichting Nationale Parken (National Parks Bonaire Foundation) |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats |

# Part I: Introduction

In this chapter, I will first present a literature review that will serve as an introduction to the problem statement. I will then introduce the case study of Bonaire, where after I discuss the research aim. After explaining the problem statement, the research objective is described with subsequent central and sub-research questions. In the final section I will present the theoretical framework that guides this research, where after I explain the methodology of this thesis.

## 1. Introduction

The Caribbean Islands have been subjected to many invasive species, which is likely to increase in upcoming years (Kairo et al., 2003; Giakoumi et al., 2019). The region has been dealing with the invasive plant species *Antigonon leptopus*, invasive sea grass *Halophila stipulacea* and the invasive seaweed *Sargassum* spp., amongst others (Huisman et al., 2021; Viana et al., 2019; Van Tussenbroek et al., 2017). The invasive lionfish has been ranked as a high risk for Caribbean regions due to the lack of natural predators and the rapid growth rate of individuals (Tidbury et al., 2021; Bumbeer et al., 2018).

Within the scientific literature, many have expressed concerns about the potential of invasive lionfish to ecologically harm their novel marine ecosystems (Harris et al., 2020; Harris et al., 2019; Clements et al., 2021; De León et al., 2013; Albins & Hixon, 2008; Ali et al., 2013; Andradi-Brown et al., 2017; Dahl et al., 2016; Hardison et al., 2018; Burgess et al., 2021; Linardich et al., 2021; Chapman et al., 2016). The ramifications of the species' proliferation could lead to a reduction in native reef fish, changes in coral reef community dynamics, and declines in coral cover. In the event that the aforementioned effects do indeed develop, the fisheries sector would undergo economic damage in the form of reduced fish yields and higher management costs (Harris et al., 2019; Clements et al., 2021; Burgess et al., 2021). As a result, fisheries and related businesses would suffer financial losses, and those that were to consume those fish, namely tourists and local inhabitants, would miss out and have to opt for imported fish (Burgess et al., 2021; Debrot & van den Burg, 2019). Moreover, as marine tourism on islands generally depends on ecological values, when invasive marine species cause for an imbalance in the native reef environment, this could affect the island's economy as reefs deteriorate and subsequent tourism value decreases (Russell et al., 2017; Campbell et al., 2016). Russell et al. (2017) state that the emergence of invasive species could both lead to costs and opportunities for managing invasive species. Nisa et al. (2022) further elaborate on this by highlighting the importance of including scuba divers in marine invasive species removal efforts.

Scuba divers have often been included in the management strategies aimed to contribute to conservation in marine protected areas (MPAs) (Lucrezi et al., 2017). De Groot and Bush (2010) emphasize the importance of the private sector, with dive operators in particular, as a crucial stakeholder group in advocating for marine conservation. Specifically, the private sector has a significant economic interest in maintaining a healthy marine environment (De Groot & Bush, 2010). Initiatives of the private sector provide a source of funding and labour for conservation and restoration activities in MPAs, and have often been referred to as 'entrepreneurial conservation' (Bush et al., 2017).

The Caribbean region employs various management strategies with the goal of eradicating or managing lionfish populations (Giakoumi et al., 2019). Graham and Fanning (2017) studied the lionfish management plans of several Caribbean islands, including

Anguilla, The Bahamas, Cayman Islands, Grenada, St. Eustatius, St. Lucia, St. Vincent and the US Virgin Islands. Most of the management plans include aspects of education, control and monitoring protocols as well as research and information management. For instance, in a case study on The Bahamas, Holdschlag and Ratter (2016) mentioned the creation of an online portal for reporting sightings, raising public awareness by organising workshops and meetings, and the endorsement of lionfish derbies and lionfish recipes. These management efforts involve a variety of sectors including government institutions, non-governmental organisations (NGOs), the fishing industry, the tourism industry, and restaurants.

Graham and Fanning (2017) have explored the many different management strategies that are employed to control lionfish populations, and found that lionfish numbers are still increasing and their impact in the Caribbean region accelerating despite many countries implementing various control strategies. The continuous spread of invasive lionfish might suggest the necessity of a continued effort of outreach since Tidbury et al. (2021) stated that MPAs of Caribbean small island developing states are at high risk of introduced non-native species that may impact and threaten conservation goals. Continuous research is therefore necessary to bridge information on how to enhance strategies for the conservation of marine biodiversity and the maintenance of environmental and economic stability (Tidbury et al., 2021). Hence, in this thesis I will analyse one of those management control strategies that involve the inclusion of the scuba dive tourism industry aimed to support the conservation objectives of the Bonaire National Marine Park (BNMP). The small Caribbean island of Bonaire was selected as a case study because tourism is an important driver for the island's economy and relies on certain ecological values that represent a healthy marine environment (Hodeck et al., 2021; Wolfs et al., 2015).

## Introducing: Bonaire, where marine tourism meets lionfish control

Off the northern coast of Venezuela lies the island of Bonaire (*See **Fig. 1***). Bonaire is part of the Caribbean Netherlands and comprises 21,745 inhabitants (Statista, 2022). Bonaire is considered by many as *the* diving destination of the Caribbean (Hall, 2020). In 2021, Bonaire's inbound visitors nearly reached a total of 260,000 air passengers, and welcomed 56,600 cruise passengers (CBS, 2022). Regarding the cruise passengers, Wolfs et al. (2015) mention the fact that it is difficult to determine exactly how much of the tourist expenditures remain on Bonaire, when it comes to land-based tours. This is because most of these tours are sold on the ships through the cruise companies. In general, most tourists are either Dutch citizens (both European citizens as well as those from the former colonies of Aruba, Curaçao, and Sint Maarten) or United States citizens (CBS, 2021). Bonaire's tourism industry caters primarily to cruise tourists and those interested in water sports including scuba diving, snorkelling, and wind and kite surfing (Nelson, 2020). Of all stay-over visitors, nearly 60% of tourists are returning visitors (Wolfs et al., 2015). A study done on the determinants of holiday enjoyment on Bonaire highlighted the importance of marine wildlife attributes such as coral and fish diversity and abundance (Uyarra et al., 2005). It is therefore of utmost importance to maintain a healthy marine environment, since tourism is an important driver for the island's economy (Hodeck et al., 2021; Wolfs et al., 2015).


**Figure 1**. Location of Bonaire in the Caribbean Sea

Over the last decades Bonaire's reef has undergone changes in terms of reef degradation that include a decline in coral cover and coral bleaching events (Steneck, et al., 2019; Webb et al., 2021; González-Díaz et al., 2018). Moreover, in less than two decades, the invasive lionfish has managed to make its way to the southern Caribbean and is now thriving. The Indo-Pacific lionfish was first introduced to Florida waters in the early 1990s, as a result by either the aquarium trade or through shipped ballast water (Albins & Hixon, 2008; De León et al., 2013; Linardich et al., 2021). The species proliferated, and spread out across the Western Atlantic Ocean. On the island of Bonaire, the lionfish was first sighted in late 2009 (De León, 2013).

The introduction and expansion of the lionfish was followed by subsequent management responses. Following the first sighting in 2009, Stichting Nationale Parken (STINAPA), which is an NGO responsible for managing the BNMP, started lobbying with the government and organised informative workshops for the public (STINAPA, 2018). In September 2010, a new spearfishing legislation was passed that allowed for people to hunt lionfish. Active removal efforts were organised and STINAPA provided approximately 300 local volunteer divers with training to hunt and kill lionfish using modified spearguns (De León, 2013; Frade et al., 2019; Clements et al., 2021). STINAPA also facilitates regular removal tournaments, known as derbies that involve dive centres, recreational divers, tourists and other volunteer divers (Malpica-Cruz et al., 2016; Clements et al., 2021).

Aside from these management control efforts and changes in the marine environment, the presence of the invasive lionfish also influenced other socio-cultural behaviours. The lionfish has become part of the human diet, and is now being sold in restaurants and hotels (*See **Fig. 2***) (Clements et al., 2021; Lionfish.co, n.d.). The lionfish is in fact a very sought after specialty for tourists, as they feel they are helping out the environment by consuming the invasive species (Debrot & van den Burg, 2019). Dive centres have also acted in response to the invasion by offering an alternative dive specialty, called the PADI Distinctive Lionfish Hunter Specialty course (Buddy dive, n.d.; Beyond the Corals, 2021; Reef Divers Bonaire, n.d.; AB Dive, n.d.; VIP Diving, 2022; 4WheelDiving, n.d.; Technical Diving Services, n.d.; Dive Diva Bonaire, 2022; Belmar Bonaire, n.d.; Sunrentals Bonaire, n.d.). Furthermore, a Curaçaoan based company processes the lionfish into jewellery and offers it to retailers throughout the Caribbean, including Bonaire (Lionfish Caribbean, n.d.).


**Figure 2**. Lionfish Burgers at Cactus Blue Bonaire (Tripadvisor, 2022)

The current situation of the assumed threat that the invasive lionfish pose on the marine ecosystem, suggests continuous efforts are necessary to contain the problem. STINAPA's latest social media message posted on Facebook on March 7th, 2022, mentioned an increase in lionfish populations, announcing that ''*after many years with low density, fewer than 40 fish per hectare (10,000 m$^2$) of the reef, the results from 2021 showed an increase in density*''. Bosman (2022) did comment by stating that within recreational waters, the population is rather under control. Bertuol (*See **Fig. 3***), biologist at STINAPA (2022) confirmed for the shallow reef water lionfish populations to be under control, thanks to the regular culling initiatives (Carballo-Cárdenas, E., personal communication, March 11, 2022). Complete eradication of the invasive species will be impossible, due to the depths that the lionfish occur at, which are beyond the reach of recreational divers (De León et al., 2013; Bumbeer et al., 2018; Harris et al., 2020).

**Figure 3**. Paulo Bertuol, Annual Lionfish Survey (Facebook, 2023)

## Research Aim

As the introduction of the lionfish into the Atlantic Ocean and beyond is a fairly new problem, so are the management strategies aimed to combat this problem. It is therefore important to undertake analyses as time goes on. When it comes to business-led control efforts such as Lionfish Hunter Specialty courses on Bonaire, little is known about the nature of this practice and its consequences. The practice of dive tourism-led lionfish control on Bonaire has therefore been chosen as a case study, in an effort to take a closer look at the consequences of the practice and the implications this holds for the conservation objectives of the BNMP. This study adds to the existing literature regarding MPA management with, in particular, marine invasive species management involving the dive tourism industry. The objective of this study is to broaden understanding of dive tourism-led lionfish control by investigating the nature of engaging in a Lionfish Hunter Specialty course, and analysing its intended and unintended consequences in relation to the conservational objectives of the BNMP.

## Research Questions

In order to reach the research objective, the following central question is addressed:

*How do SCUBA Lionfish Hunter Specialty courses contribute to lionfish control efforts and what are the implications of such business-led practices for meeting the conservation objectives set by the Bonaire National Marine Park?*

To attempt to answer the central question, the following sub-research questions are formulated:

1. What are the current objectives of STINAPA when it comes to invasive lionfish?

2. How does the practice of engaging in a SCUBA Lionfish Hunter Specialty course look like?

3. What are the enabling factors (i.e. competences, materials and meanings) that allow for engagement in a SCUBA Lionfish Hunter Specialty course to take place?

4. What are the intended and unintended consequences resulting from the interactions of engaging in a SCUBA Lionfish Hunter Specialty course?

## 2. Theoretical Framework

Within tourism literature, Social Practice Theory (SPT) has been widely used to explain and describe tourism activities (Bargeman & Richards, 2020; Xu et al., 2021). Instead of focussing on the individual actors within a tourism practice, social practices themselves are taken as the starting point for conducting research (Lamers et al., 2017; Hargeaves, 2011). As Giddens, one of the early theorists on SPT, proposed, social practices should be featured as ''*the basic unit of social enquiry*'' (1984, as cited by Shove & Walker, 2014).

In order to apply the SPT, the first step is to define what a 'social practice' entails. In essence, a practice can be understood as a routinised type of collective behaviour, which can consist of several interconnected elements that include individuals as the carriers of the practice, and material objects such as technologies and infrastructures (Lamers et al., 2017; Bargeman & Richards, 2020; Shove & Walker, 2014; Xu et al., 2021; Alonso et al., 2018). Furthermore, intangible elements to consider involve certain skills, understanding and background knowledge needed to perform the practice, as well as states of emotions, motivational knowledge, symbolic meanings and shared norms. An important element to consider is that social practices are dynamic; they are prone to change over time and within different environments (Sahakian & Wilhite, 2014; Bargeman & Richards, 2020).

### Materials, Competences and Meanings

Within existing literature on SPT, Shove et al. (2012) have proposed a framework for identifying and characterising social practices that has reached consensus amongst social scientists (Lamers et al., 2017; Nicolini, 2012; Xu et al., 2021). It has been agreed upon that a social practice can be characterised by combining the following three elements: **materials** (e.g. tangible objects, the environment, resources, infrastructure, technologies), **competences** (e.g. skills, understanding, background knowledge, rules, techniques, procedures), and **meanings** (e.g. symbolic meanings, ideas of people, aspirations, states of emotions, motivations) (*See **Fig. 4***) (Lamers et al., 2017; Bargeman & Richards, 2020; Xu et al., 2021; Hargeaves, 2011). These three elements are the enabling factors, or basic principles, that allow for a social practice to take place. As Shove et al. (2012) indicate, and is agreed upon by many others, applying three elements to analyse a social practice does so at the expense of reducing and oversimplifying a complex matter over merely three components (Lamers et al., 2017; Spaargaren et al., 2016; Bargeman & Richards, 2020). However, although simplified, Welch and Warde (2015) point out that applying this approach presents an opportunity to analyse and explain complex dynamics in detail.

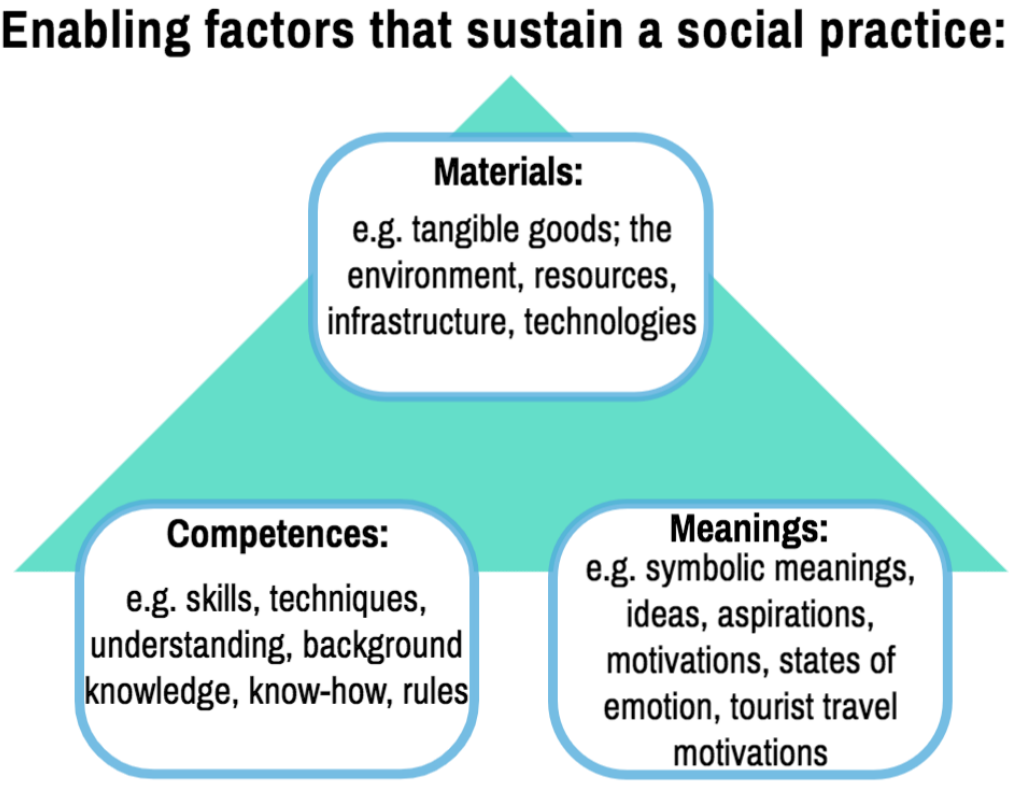


**Figure 4**. Conceptual Model of the Social Practice Theory framework by Shove et al. (2012)

This thesis intends to apply the SPT approach to the case of business-led lionfish control efforts on Bonaire, to create a deeper understanding of the social practice that involves engaging in a scuba Lionfish Hunter Specialty course and its consequences. As Shove et al. state, practice theory has the potential to understand change (2012, as cited by Alonso et al., 2018). In the case of Bonaire, the government, civil society, and the dive tourism sector created a collective response after the invasive lionfish was first spotted in 2009. Responding to the perceived threat of the invasive lionfish can be seen as the emergence of a new social practice, in the sense of dive operator-led lionfish control via the specialty course. Applying a SPT approach would therefore be an appropriate means to further understand this practice and the implications it carries with respect to the BNMP's conservation goals. Moreover, as Nicolini (2012) highlights, applying a practice-based approach offers the opportunity of defining a practice without describing the world in terms of irreducible dualisms such as social/material or supply/demand. This approach recognises that one cannot exist without the other and are in fact two sides of the same coin. Moving away from a singular focus on either 'side', and instead embracing the social practice as a whole, practice theory allows for a more holistic and grounded perspective (Hargreaves, 2011; Xu et al., 2021).

### Intended and Unintended Consequences

Building on the literature reviewed and encouraged by the aforementioned simplicity gap that reduces a social practice to the three elements of materials, competences and meanings mentioned by Shove et al. (2012), Lamers et al. (2017), Spaargaren et al. (2016) and Bargeman and Richards (2020), this study intends to broaden understanding of the social practice by incorporating the notes of Bargeman and Richards (2020). As Bargeman and Richards (2020) point out, every practice generates certain consequences for both the

actors and context. Solinas-Saunders and Stacer (2015) highlight the importance of paying special attention to these consequences, for these consequences are fed back into the system that produced them, contributing to the behaviour of further social interaction. Giddens first coined the term 'unintended consequences' as unforeseen side effects (1984, as cited by De Zwart, 2015). The 'intended consequences' involve the goals, expectations or purposes of the actors regarding their actions (Bargeman & Richards, 2020). Both intended and unintended consequences may be perceived as positive and/or negative. In other words, a social practice may lead to **intended consequences** that could either be perceived as positive or negative. The **unintended consequences** could also be perceived as positive or negative. Therefore, when classifying the consequences of a practice, these could fall in either four of the categories, i.e. A) intended consequences that are perceived as positive, B) intended consequences that are perceived as negative, C) unintended consequences that are perceived as positive, and D) unintended consequences that are perceived as negative.

For the purpose of this study, the concept by Bargeman and Richards (2020) and Solinas-Saunders and Stacer (2015) will be adopted as to provide categorisation to the intended and unintended consequences stated by respondents. By applying these four categories each consequence is able to take on a position to that similar of a strengths, weaknesses, opportunities and threats (SWOT) analysis (*See **Fig. 5***) (Namugenyi et al., 2019). Combining these theoretical concepts will result in a matrix that could be used for practical purposes. As Namugenyi et al. (2019) suggest, a SWOT analysis can be used to organise strategic planning when designing and promoting new strategies, formulating government policies and legislations, amongst others.

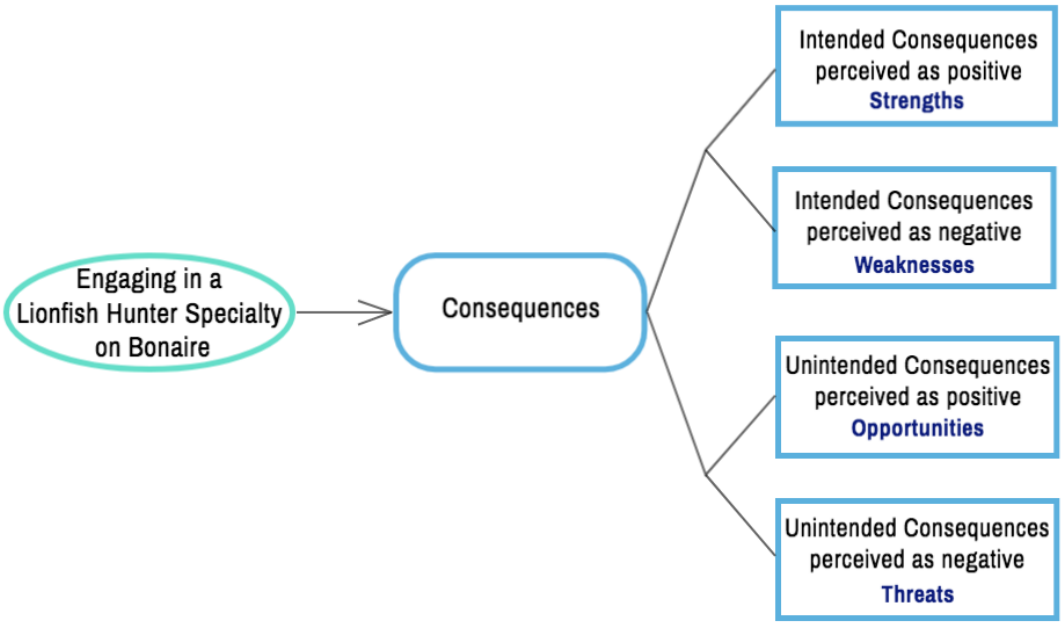


**Figure 5**. Conceptual Model based on the proposed theory by Giddens (1984), Bargeman and Richards (2020), and Solinas-Saunders and Stacer (2015), applied to the case of business-led lionfish control practices on Bonaire

### Bundles of Practice

Another aspect of SPT is defining the **bundles of practice**. Various routines and actions that make up the core practice can be understood as bundles of practice (Lamers et al., 2017). When using scuba dive tourism as an example, a bundle of practice could be setting up scuba gear to prepare for a dive. A more extended approach to SPT can further lead to distinguishing **practice-arrangement bundles** (Shove et al., 2015; Schatzki, 2016; Lamers et al., 2017). These are to be understood as doings, actions, and material arrangements that are interconnected and supportive of the core practice. Each social practice is co-dependent on one another and thus allow for the on-going enactment of those practices. Building on the scuba dive tourism example, here, a practice-arrangement bundle could be the supply of scuba air tanks. The delivery of scuba air tanks may not be part of the core practice that is the actual dive, but is an essential and supportive act of the core practice. Lastly, when a practice-arrangement bundle is anchored at a specific place such as airports or hotels, Shove et al. refer to them as **complexes** (2012, as cited by Lamers et al., 2017). For this thesis, it may prove beneficial to identify these complexes for they are part of a social practice and its acknowledgement may help broaden understanding of the practice as a whole.

### Zooming-in vs. Zooming-out

A final component of SPT includes the principles of **zooming in** and **zooming out**. Through contextualisation and hypothesising, the method of zooming in and zooming out is an iterative process and allows one to observe and uncover a trail of connections between various bundles of practice (Worline, 2012; Nicolini, 2009). By zooming in, the details that make up the practice are established whereas zooming out may lead to understand the broader effects and dynamics that are influenced by the core practice.

All in all, SPT has been selected to study the core practice of engaging in a Lionfish Hunter Specialty course on Bonaire, for through this lens linkages can be established between the bundles of practice, their actors, and the greater context the practice is embedded in (Bargeman & Richards, 2020). For practical purposes, I decided to add to the concept proposed by Bargeman and Richards (2020) and Solinas-Saunders and Stacer (2015) who initially proposed two types of consequences a practice can lead to. Instead of two, this thesis will apply four categories and by adopting the framework of a SWOT analysis, further classification is possible that may be used for practical implications. On the following page, **Figure 6** depicts for the conceptual model that underpins this research.

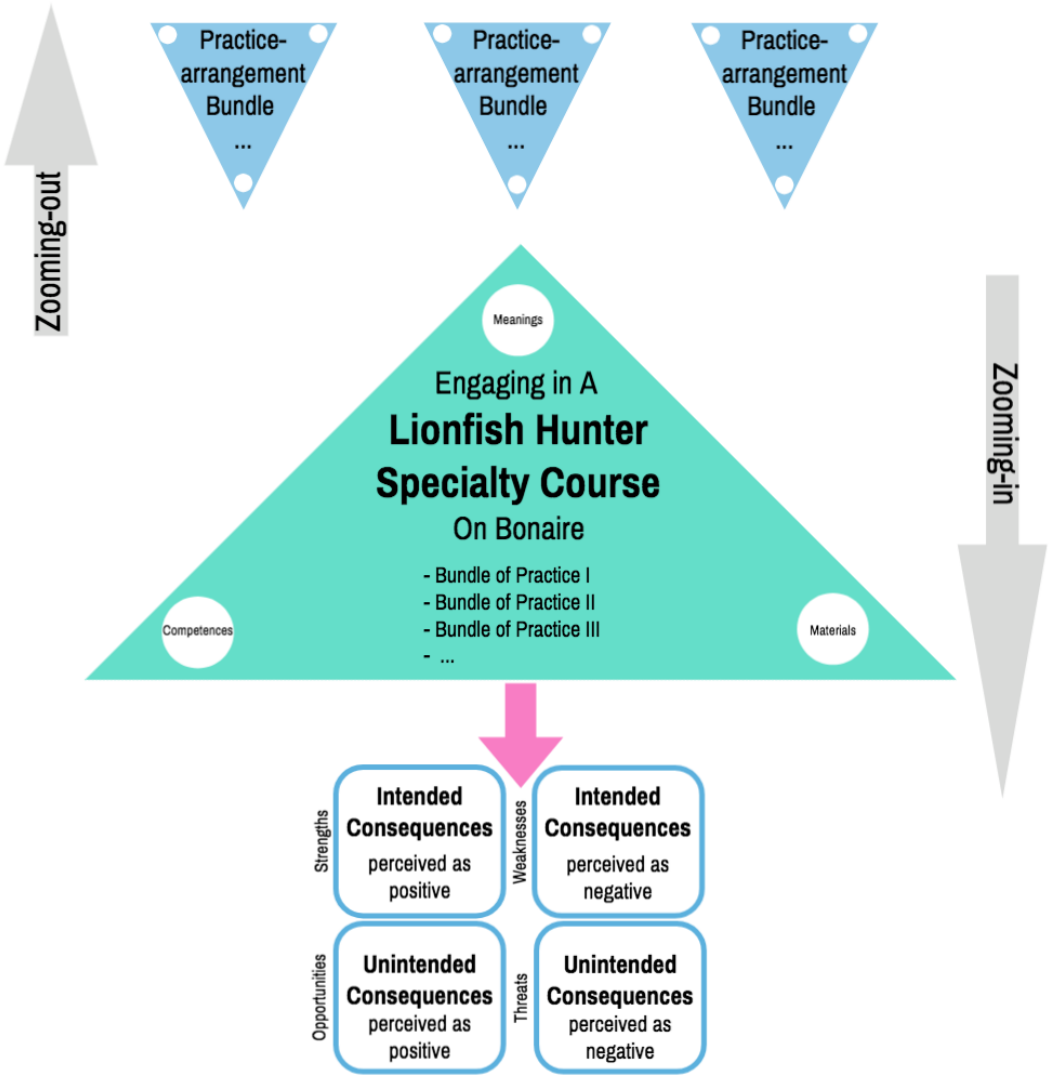


**Figure 6**. Conceptual Model based on the theory by Shove (2012), Giddens (1984), Bargeman and Richards (2020), and Solinas-Saunders and Stacer (2015), applied to the case of business-led lionfish control practices on Bonaire

## 3. Methodology

Now that I described the theoretical framework that underlies my research, I will explain the methodology I employed to attempt to answer my research questions. Aside from the data collection methods I will also explain the manner in which I analysed those data. In short, my thesis centred around a qualitative research approach, incorporating desk research, observations and interviews. The fieldwork was conducted within four weeks, in the period between 28 June 2022 and 29 July 2022.

### Desk Research

Desk research was used to study the destination in depth and conduct a preliminary research prior to entering the field. Additional information that I failed to ask during the interviews, such as course prices for instance, were also found with the help of desk research. After finalising the results, I conducted desk research to find scientific articles that I could compare the results to.

### Participant Observation

As Schwartz and Schwartz described (1955), the observer is part of the context being observed. Over the course of the fieldwork, I have observed my surroundings and used a field diary to collect detailed notes and thoughts on the matter (Clifford et al., 2016). I frequently revisited these notes to refresh my memory and to see the evolution of my thinking and that of the observed phenomena. Having followed an interpretive approach, within a social context, truth and knowledge are always subjective as well as it depending on the cultural and historical context, based on the experience of people and their understanding of them (Ryan, 2018). Hence, for the reason of the social world being an interpreted world, truth, meanings and knowledge can always be subject to change (Altheide & Johnson, 2011).

I furthermore immersed myself in a couple of participant observation sessions. After each session, I wrote detailed descriptions down in my dive logbook to ensure validity of the results. I did not have the impression of having gathered enough data through the participant observation sessions to provide any generalisations on the matter and have therefore not reported on those experiences in further detail in the results chapter that follows. Furthermore, this decision was also based on the fact that I observed several *assisted* lionfish hunting dives, but I did not witness engagement in the PADI Distinctive Lionfish Hunter Specialty course. In **Appendix 1**, a table with a brief overview is shown of the participant observation sessions I engaged in with subsequent field notes.

Even though I made the decision of not reporting extensively on my participant observations under water, I did use my observations for further probing questions during interviews. Moreover, the participant observation allowed me to get closer to the practice and observe the practice-arrangement bundles that support it.

### Interviews

As Kallio et al. state (2016), semi-structured interviews allow for the interviewer to gain a rich understanding of the phenomenon to be studied. Semi-structured interviews allow for a dynamic and flexible interaction while leaving space for probing questions. Prior to

conducting fieldwork, I contacted over thirty practitioners via E-mail, ten of which responded and ended up as interviewees. The remaining respondents I contacted after my arrival via the snowball method with the help of my respondents and other contacts met on site (Dosek, 2021).

Over the course of four weeks, a total of nineteen in-depth semi-structured interviews have been collected. Respondents included the government, civil society, and private actors involving the dive tourism industry. The latter included dive operators, dive instructors, and personnel working at scuba dive resorts. Of all the interviews, three were administered via E-mail, one via a WhatsApp video call and the remaining were conducted in person. Apart from the E-mails, all interviews were voice recorded and transcribed immediately after to ensure validity and reliability of data. See **Appendix 2** for an example of a semi-structured interview guide. As time went on and interviews accumulated, however, interview questions kept changing and adapting depending on the person I was interviewing. Underneath in **Table 1**, the respondent list is shown. In total, there were four respondents that preferred to remain anonymous. Hence, any information that could point to their identity has been omitted.

**Table 1**. Respondent List

| Respondent No. | Name, Surname | Occupation, Institution | No. of years on Bonaire |
|---|---|---|---|
| **1** | Edison Rijna | Lt. Governor of Bonaire | Native Citizen |
| **2** | Paulo Bertuol | Wildlife Biologist at STINAPA | 12 years |
| **3** | Fernando Simal | Director and founder of WildConscience | 23 years |
| **4** | ANONYMOUS | Dive tourism industry | - |
| **5** | ANONYMOUS | Dive tourism industry | - |
| **6** | ANONYMOUS | Dive tourism industry | - |
| **7** | Bas Tol | Dive Master, owner of Bas Diving | 30 years |
| **8** | Charles Vos | Dive Master, General Manager at Grand Windsock (WannaDive) | 12 years |
| **9** | Eric de Vries | Dive Shop Manager at AB-Dive | 9 years |
| **10** | Hagen Wegerer | Dive Master, Operations Manager at Plaza Marina (Toucan Diving) | 21 years |
| **11** | Yago Fernández Gutiérrez | Dive Instructor, owner of 4WheelDiving | 5 years |
| **12** | ANONYMOUS | Dive industry | - |
| **13** | Dee Scarr | Dive Instructor, Lionfish Hunter, author, marine naturalist, now retired | 43 years |
| **14** | Nicholas Bachman | Dive Instructor at WannaDive | 1 year |
| **15** | Pascal van Empelen | PADI Course Director, Dive Operations Manager at Divi Resort (Divi Dive Bonaire) | 11 years |
| **16** | Jurgen Pfalz | Dive Instructor, owner of Jurgen Reef Divers Bonaire | 7 years |
| **17** | Nouschka Snijders | Dive Instructor at AB-Dive | <6 months |
| **18** | Bart Linders | Dive Instructor, Director at Dive Friends | 17 years |
| **19** | Joseph Talbol Bixby | Inventor, Lionfish Hunter | - |

| **Legend** | |
|---|---|
| | Government |
| | Civil Society |
| | Private Actors |
| | Other |

For the first round of transcribing the interviews I played the recording of each interview and used the MS Teams option of providing me a transcript. I then played the interview recording a second time and made further corrections until the transcripts were complete. After having successfully transcribed all nineteen interviews, I applied thematic analysis to identify patterns and themes within the data (Evans, 2018). A combination of both inductive and deductive analysis was used to assign codes to each interview fragment.

In summary, over the course of four weeks I conducted my fieldwork. The qualitative research techniques that led me to answer my research questions included desk research, participant observation and nineteen in-depth semi-structured interviews with people from the government, civil society, private actors within the dive tourism sector, and others.

# Part II: Research Findings

## 4. Introduction to the Establishment of the Specialty Course

### 4.1. A Historical Timeline

Being surrounded by ocean, the island community of Bonaire has been depending on and interacting with marine life throughout history. Changing practices revolving around fishing have been evident and will continue to do so as time goes on. When it comes to the introduction of the lionfish into Bonaire's waters, we need to go back to 1971 to see how this interaction begun, and how it has morphed into the human-marine life dynamic that is presented today.

**1971**

Spearfishing ban was put in place (Respondent #1, 2022; Respondent #2, 2022)

**Pre-2009**

Marine Park Manager Ramón de León created the lionfish control plan for Bonaire (Respondent #2, 2022)

- Phase I of the Lionfish Management Plan initiated

**2009**

April: government initiatives aimed to raise awareness amongst the dive industry, informative workshops were given (Respondent #2, 2022)

October 26: first lionfish spotted / first time someone spots and collects a lionfish on Bonaire (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022, Respondent #18, 2022)

- Phase II of the Lionfish Management Plan initiated
- Divers were asked to spot, mark and report lionfish that would afterwards be removed by BNMP staff using nets
- Information was uploaded to the 'death row' database
- BNMP staff began training volunteers in lionfish removal techniques and rangers held more than 40 training workshops
- Residents and sédula holders had to put in a request with STINAPA to obtain a lionfish-hunting permit. BNMP staff would provide one-on-one training, including three dives, where after they would give either a negative or positive advice. Those that were given a positive advice were issued an ELF with corresponding serial number (Respondent #8, 2022; Respondent #13, 2022) See **Figure 7** for the first lionfish hunting certification card.


**Figure 7.** Lionfish Hunting Permit (Respondent #2, personal communication, July 25, 2022)

**2010**

Bonaire becomes a special municipality of the Netherlands (Respondent #2, 2022)

- September: spearfishing legislation was changed; now empowering the marine park manager to decide what kind of spearfishing tool will be allowed for the volunteers hunting lionfish

> *Section IV*
> *ARTICLES CONCERNING FISHING*
>
> *Article 9*
> *1. It is forbidden to use mechanical gear, explosives, hand spears or poles with hooks, to hunt or catch marine life.*
>
> *6. With the exception of explosives, the prohibitions set forth in paragraph 1, 2 and 3 do not apply to the Manager or to the persons assigned by the Manager, upon catching, gathering and killing of harmful species as referenced in paragraph 1, Article 19 of the Island Resolution Nature Management Bonaire.*

**Textbox 1.** Spearfishing Legislation Bonaire

- First prototype of the mechanical spear was designed by Bixby, made out of bicycle parts, known as the ELF tool: Eliminate Lionfish (Respondent #19, 2022)
- ELF tool got modified by Tol, who installed a trigger system (Respondent #7, 2022; Respondent #13, 2022; Respondent #19, 2022)

**2011**

Local volunteers receive workshops, training, and more than 300 ELFs were distributed by the BNMP (Respondent #2, 2022)

**2012**

Initiated by the Council of Underwater Resort Operators (CURO) that represents Bonaire's dive operators, together with STINAPA they created the PADI Lionfish Hunter Specialty course, allowing tourists to spear lionfish (Respondent #2, 2022; Respondent #8, 2022; Respondent #13, 2022)

- Tourists are allowed to use ELFs during the course and are permitted to hunt after certification assisted by a local dive guide
- Lionfish hunters start using Zookeepers to store the lionfish

**PRESENT**

Dive centres continue to offer the Lionfish Hunter Specialty course (Respondent #2, 2022)

- Lionfish hunting permitted everywhere expect for in the reserves
- Restaurants offer lionfish on the menu
- In order to maintain a low density and to keep the volunteers motivated, the BNMP opens up the dive reserves annually to allow for lionfish hunting

## 4.2. Conservation Objectives of the Bonaire National Marine Park

When newly introduced species enter the island's ecosystem, they receive either one of the two labels. Where **exotic species** pose no threat to native species, **invasive species** do. It's the invasive species that negatively impact native ecosystems (Respondent #2, 2022; Respondent #3, 2022). In the case of Bonaire, the lionfish was deemed an invasive species. They were classified an invasive species prior to knowing whether it would negatively affect the reef. STINAPA applied the **Precautionary Principle** while they anticipated for their arrival.

*"So, it's a problem. How serious is the problem? We're (sic) still not 100% sure. But we need to use the [...] Precautionary Principle" for when "you don't know if that species will be a threat for the local nature, consider that, probably, yes"*
(Respondent #2, 2022)

Within nature conservation, there are two ways of managing an invasive species. You can either eradicate, or control (Respondent #2, 2022; Respondent #3, 2022). To control the lionfish density was the chosen management strategy.

Wildlife biologist Bertuol from STINAPA, who dedicates his time mainly to working with invasive species, stated the following two objectives for the BNMP that concern the lionfish: (a) overfishing of lionfish to create a low density, and (b) creating an incentive for the dive tourism industry (2022). By offering the scuba Lionfish Hunter Specialty course to tourists, more volunteers are received, meaning more money is generated flowing into the local economy. The objectives established by STINAPA were confirmed by the Lieutenant Governor of Bonaire. Rijna stated that the objectives revolving around lionfish management includes controlling the density, and to involve tourists is to generate *''more income for the locals''* (2022). A schematic overview of the management plan STINAPA created for controlling the lionfish in Bonaire is included in **Appendix 3** (Respondent #2, 2022).

STINAPA furthermore strongly highlights two pieces of advice, designed to stimulate safe and healthy practices (Respondent #2, 2022). Firstly, not to leave dead lionfish in the water. One must use a Zookeeper at all times to avoid interactions with predatory fauna. Second, watch for signs of ulcerated fish. Direct contact should be avoided, and they should not be consumed. **Figure 8** below depicts this advice as well as the general objectives for lionfish management.

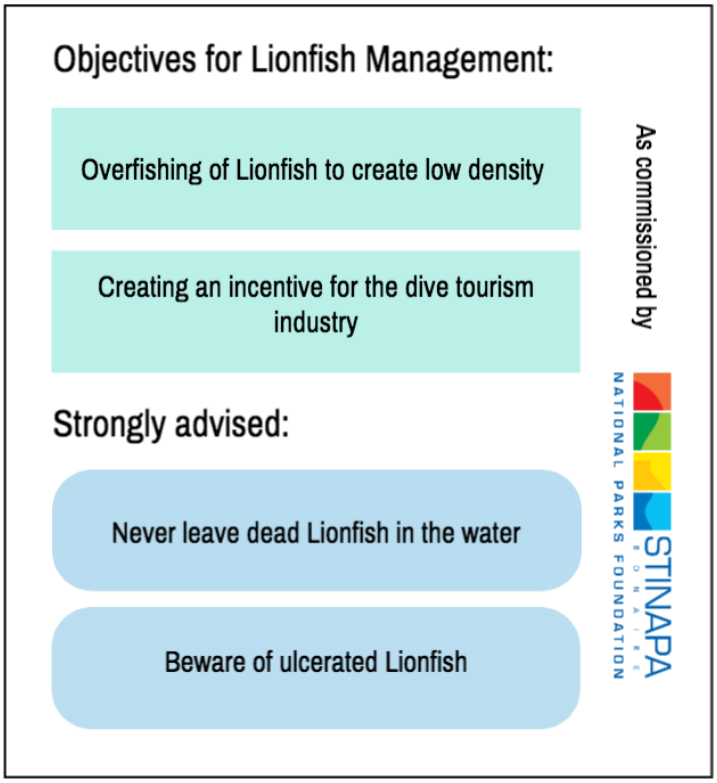


**Figure 8**. Conservation Objectives Regarding the Invasive Lionfish in Bonaire

Observation and stomach content analysis helped identify consumption patterns of the lionfish on Bonaire. Respondents most frequently mentioned '**reef fishes**' and '**small fishes**' (N=20) to be found inside the lionfish' stomach. Parrotfish, Royal Gramma, Wrasse and juvenile fish in general were included within this group. The second most frequently mentioned category was '**everything that fits into their mouths**' (N=12).

Furthermore, '**crustaceans'** (N=10) and '**invertebrates'** (N=2) were found inside their stomach, which includes a host of species, listed in **Table 2**. Further analysis revealed '**undiscovered fish species**' as well as other '**lionfish**'. In addition to **Table 2**, **Figure 9** below provides a representation of the categories most frequently mentioned by the respondents.

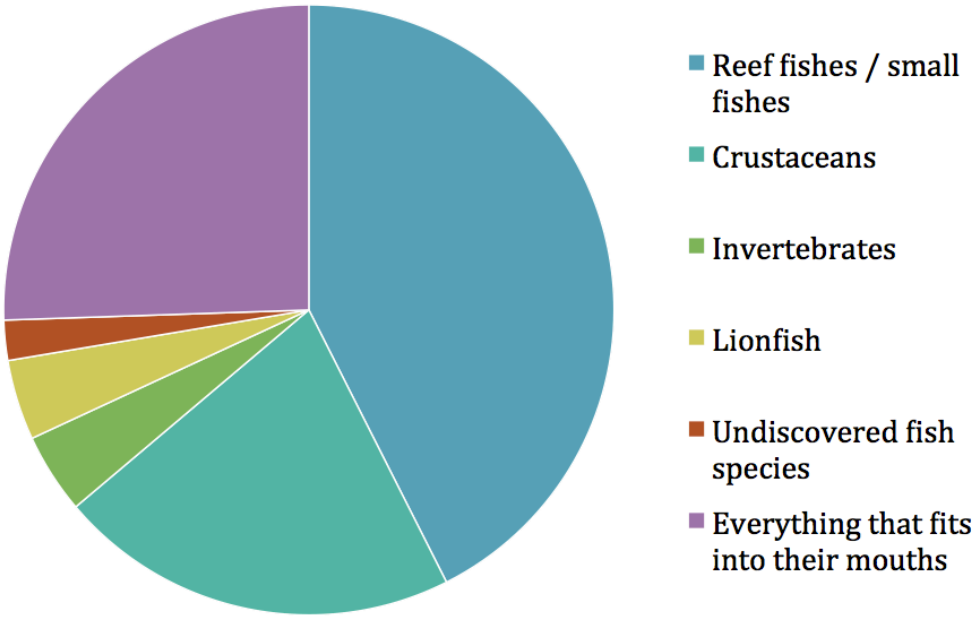


**Figure 9**. Diet Composition of the Lionfish on Bonaire

**Table 2**. Diet Composition of the Lionfish on Bonaire

| Diet Composition Lionfish | Respondent (no.) | Total (N) |
|---|---|---|
| Reef fishes / small fishes | 1, 2, 9, 12, 14, 15 | 6 |
| Parrotfish | 1, 7, 12, 15, 16 | 5 |
| Royal Gramma (Fairy Basslets) | 10, 14 | 2 |
| Wrasse | 14 | 1 |
| Juvenile fishes (incl. Parrotfish, Barracuda, Grouper) | 3, 7, 8, 11, 12, 18 | 6 |
| Crustaceans | 3, 16 | 2 |
| Shrimp | 3, 12, 14 | 3 |
| Lobster | 3 | 1 |
| Crabs | 14 | 1 |
| Small cleaner fish | 7, 10, 11 | 3 |
| Invertebrates | 3 | 1 |
| Octopus | 3 | 1 |
| Lionfish | 13, 19 | 2 |
| Undiscovered fish species | 1 | 1 |
| 'Everything that fits into their mouths' | 1, 3, 6, 7, 8, 9, 10, 11, 12, 14, 17, 18, 19 | 12 |
| | | 47 |

The lionfish consumes fish depending on the size of the lionfish (Respondent #14, 2022). Overconsumption of juvenile Parrotfish, Barracuda and Groupers could negatively affect native reef fish dynamics that these animals support. Parrotfish form an important part of the reef for these grazing herbivores prevent algae from overgrowing and suffocating the corals (Respondent #1, 2022; Respondent #7, 2022; Respondent #11, 2022; Respondent #15, 2022; Respondent

#15, 2022; Respondent #16, 2022). Predatory species like Groupers are highly valued for their numbers have been declining over the years (Respondent #2, 2022). The overconsumption of shrimp and other type of cleaner fish could impair the supportive dynamics that these animals foster (Respondent #7, 2022; Respondent #10, 2022; Respondent #11, 2022). A lack of cleaner fish could inhibit coral reef fish from staying healthy and are thus more prone to suffer from infections or skin diseases (Respondent #7, 2022). Moreover, the overfishing of small fish could also pose threats to other ecosystems, such as seabird colonies like Terns that rely on those fish (Respondent #3, 2022).

Due to the fact that the lionfish has been labelled an invasive species (N=17), and with concern for all the potential threats the lionfish could pose to the reefs of Bonaire, the decision was made to implement the Precautionary Principle and aim to control the lionfish by means of human culling efforts. In order to meet this objective, a collaborative effort was established between the government, civil society, and private actors implying the dive tourism industry.

# 5. A Description of the Specialty Course

## 5.1. PADI Distinctive Specialty Course: Lionfish Hunter in Bonaire

This specialty course is not a standardised PADI course that is taught all around the world at coastal destinations that harbour the invasive lionfish. This PADI Distinctive Specialty course was written specifically for the island of Bonaire, and certification cannot be utilised to hunt lionfish outside of Bonaire (Respondent #14, 2022). Trained and licensed dive operators are allowed to offer the specialty, and follow the course set-up, outlined by PADI. Each participant of the course needs to go through a series of steps to obtain certification, while at the same time leaving the dive operators the liberty and flexibility of *how* to teach this course. Each dive session needs to last a minimum of twenty minutes, which is an official prerequisite by PADI (Respondent #10, 2022). Moreover, all dives are confined to depths of a maximum of 18/30 metres, depending on the participants' obtained dive certification (Respondent #9, 2022; Respondent #11, 2022). Despite the name of the course, this specialty is more to be considered a means of awareness and education opposed to becoming an actual lionfish hunter (Respondent #18, 2022). This is because the tourists do not have the option of becoming active lionfish hunters after certification, for they are not allowed to hunt on their own (Respondent #8, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022). Furthermore, it is not a performance requirement of the distinctive specialty to actually shoot or kill a lionfish (Respondent #17, 2022; Respondent #18, 2022).

In general, the specialty is a one-day course, taught anywhere between sunrise and sunset, and includes two dives (Respondent #9, 2022; Respondent #15, 2022; Respondent #17, 2022). Before the start of the course, participants are required to fill out standardised PADI paperwork (Respondent #15, 2022; Respondent #17, 2022). The specialty course is divided in two parts, with Part I focusing on theory (Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022). The participant will be educated on the history of the lionfish, how it arrived on Bonaire and the implications of this. The educational aspect of the course is centred around raising awareness, and each dive operator is able to decide what kind of information they convey and in what manner. A general knowledge review concludes the theoretical part (Respondent #10, 2022; Respondent #15, 2022; Respondent #17).

During Part II the participants move away from the classroom and receive their first hands-on experience. The course materials concerning the ELF and Zookeeper are explained, as well as additional information and tips on how to avoid getting stung by lionfish or to be wary of moray eels (Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022). Afterwards, participants practise shooting on dry land and learn how to operate the trigger system. Once the participant is familiar with the tools, they will execute their first hunting dive. Hunting Dive 1 takes place in the shallows, or the sandy parts of the reef. Here, the objective is to work on their aim, and practise shooting a weighted lionfish dummy. After the first dive the participants are debriefed and feedback is given on their diving abilities (Respondent #10, 2022; Respondent #11, 2022). During the conversation, the importance of relaxation is highlighted, as well as time and air management. During the second dive, everything that has been taught is put to the test. The second hunting dive focuses on searching for living lionfish and trying to shoot and catch them (Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022). Depending on group size, participants are expected to perform certain roles. During lionfish hunting, the buddy system is encouraged implying one to be the spotter, and the

other to be the hunter (Respondent #10, 2022; Respondent #11, 2022; Respondent #18, 2022). Hunting Dive 2 ends with a debrief session, and after successful completion of the course, certification is granted. Dive operators may choose to incorporate any additional elements to the course which can include lessons on how to remove the toxic spines and clean a lionfish, how to fillet, and how to prepare the fish (Respondent #10, 2022; Respondent #11, 2022). Participants are also given the option to take home their catch of the day (Respondent #16, 2022). **Table 3** below shows the course outline of the PADI Distinctive Specialty Course: Lionfish Hunter in Bonaire. The practices listed under *Part III* are optional and are thus not applied amongst all dive operators.

**Table 3**. PADI Distinctive Specialty Course itinerary: Lionfish Hunter in Bonaire

| | |
|---|---|
| **PADI Course Standards** | ➢ PADI paperwork<br>➢ One-day course, between sunrise and sunset<br>➢ Maximum water depth of 18/ 30 metres<br>➢ Each dive should last a minimum of 20 minutes |
| **Part I: Theory** | • Movies/videos: introduction and explanation of the invasive lionfish<br>• Education/ presentation/ question hour/ history of the lionfish on Bonaire/ awareness raising/ handout<br>• General knowledge review |
| **Part II: The Dives** | ▪ Explanation of the ELF and Zookeeper/ how not to get stung/ beware of moray eels<br>▪ Practise shooting a lionfish dummy on dry land<br>▪ Explanation of the buddy system (hunter vs. spotter)<br>▪ Hunting Dive 1: takes place in the shallows/ sandy part of the reef. Here the focus lies on how to aim and shoot, participant practises on a lionfish dummy.<br>▪ De-brief Dive 1: explanation of time/ air management. Importance highlighted of trying to relax, participant receives feedback on their diving abilities.<br>▪ Hunting Dive 2: attempt to find actual lionfish<br>▪ De-brief Dive 2: after feedback session, participants receive certification |
| **Part III: *Optional*** | ❖ Lionfish cleaning/ gutting tutorial<br>❖ Filleting the Lionfish<br>❖ Cook out/ recipes: ceviche<br>❖ Lionfish are brought home/ given to participant |

### 5.2. Specialty Course Requirements

The sole requirement for engaging in the Lionfish Hunter Specialty Course, according to PADI standards, is that the participant must be a certified Open Water Diver (Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #19, 2022). Certain diving competences that are important to have mastered prior to engaging in such a course, are correct trim and buoyancy control (Respondent #10, 2022; Respondent #11, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022). In case the participant does not possess the necessary skills yet, alternative courses are recommended. These include a Refresher Course (Respondent #16, 2022), the Peak Performance Buoyancy Specialty (Respondent #11, 2022) and Enriched Air Certified Nitrox (Respondent #12, 2022; Respondent #17, 2022). Because it is not a standard for dive operators to perform a screening process, some choose not to do so (Respondent #18, 2022). Nonetheless, various dive operators have chosen to undertake a screening process, to ascertain whether the participant is skilled enough to be able to take on this specialty course (Respondent #10, 2022; Respondent #11, 2022). The screening process

differs per dive operator. Where some choose to offer the course to students on the condition that they have a minimum of ten logged dives (Respondent #14, 2022), others prefer a participant with thirty logged dives (Respondent #11, 2022). Although dive operators might express for the participant to have a certain number of logged dives, in practice, they will not deny an applicant when not having met the preferred number of logged dives (Respondent #11, 2022; Respondent #14, 2022).

A frequently mentioned preference by dive operators and instructors is for participants to be certified Advanced Open Water Divers (Respondent #10, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #18, 2022). Others have stressed that the Lionfish Hunter Specialty course is not for any tourist or certified diver, and when ignored can result in harmful practices for either the reef or its participants (Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #19, 2022). As respondent #19 stated (2022):

*''A lot of divers [...] want to become a tech diver. They can't show up to Bonaire and say I want to [Sic] be a tech diver and start tech diving. There's a long process to get there. [...] Lionfish hunting isn't open water diving. It might not be tech diving. But it's definitely beyond Advanced Open Water''*

| | |
|---|---|
| • Official PADI Course Requirement: | Certified Open Water Diver |
| • Recommended Requirement by Dive Operators: | Certified Advanced Open Water Diver |
| • Alternative Recommended SCUBA Specialty Courses: | Refresher Course<br>Peak Performance Buoyancy<br>Enriched Air Certified Nitrox |

**Textbox 2.** Distinctive Lionfish Hunter Specialty Course Requirement

### 5.3. Conditions for Passing the Course

As previously mentioned, it is not an official performance requirement of the PADI specialty to successfully shoot or kill a lionfish during the course (Respondent #17, 2022; Respondent #18, 2022). Several dive operators, however, choose to not certify a participant when showcasing poor aim or failing to successfully hit a target (Respondent #6, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #18, 2022). Other dive operators do certify somewhat incompetent participants, but only after having given feedback on their diving abilities during the debrief sessions (Respondent #7, 2022; Respondent #8, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #17, 2022).

Requirements for entering the course, the course outline, and conditions for obtaining certification may vary amongst the different dive operators of Bonaire that offer the Lionfish Hunter Specialty

**Textbox 3.** Distinctive Specialty Course: Lionfish Hunter Specifications

### 5.4. Dive Operators and Instructors

According to respondent #2, approximately fifteen dive operators offer the scuba Lionfish Hunter Specialty course on the island of Bonaire (2022). Freelance dive instructors teaching the course were not included in this list. Moreover, this number might have changed since the time of writing. Hence, the exact number of dive operators and instructors that currently offer the specialty is unknown. In this case study (N=19), instructors of eight different dive operators were interviewed (Respondent #6, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #16, 2022; Respondent #17, 2022), including three respondents that have ceased to offer the specialty course, but did so in the past (Respondent #7, 2022; Respondent #13, 2022; Respondent #15, 2022). **Table 4** below provides an overview of the dive operators on the island that currently offer the specialty course.

**Table 4**. Dive Operators in Bonaire that offer the Lionfish Hunter Specialty Course

| Dive Operator | Mentioned by Respondent (no.) / Source |
|---|---|
| VIP Diving | 2, 12, 13, 15, 16 |
| Dive Friends Bonaire | 6, 8, 18 |
| Buddy Dive | 3, 15 |
| Wanna Dive | 8, 14 |
| AB-Dive | 9, 17 |
| Toucan Diving | 10 |
| 4WheelDiving | 11 |
| Jurgen Reef Divers | 16 |
| Technical Diving Services Bonaire | (TDS Bonaire, n.d.) |
| Caribbean Club Bonaire | (Bonaire Pros, 2013) |
| Dive Diva Bonaire | (Dive Diva Bonaire, 2022) |
| SunRentals Bonaire | (SunRentals Bonaire, 2020) |
| Private Divers Bonaire | (Private Divers Bonaire, n.d.) |
| Beyond the Corals | (Beyond The Corals Bonaire, 2021) |

### 5.5. Specialty Course Prices

**Table 5** provides a list of some of Bonaire's dive operators and their corresponding Lionfish Hunter Specialty course prices. As evident, the pricing differs per dive operator and those marked with an asterisk (*) exclude dive gear and air tank fills.

**Table 5**. Bonaire's Distinctive Lionfish Hunter Specialty Course Prices

| Dive Operator | Course Price (USD) | Respondent (no.) / Source |
|---|---|---|
| 4WheelDiving | 250 * | 11 |
| AB-Dive | 170 | 17 |
| Buddy Dive | 130 | (Buddy Dive Bonaire, 2023) |
| Beyond the Corals | 149 | (Beyond the Corals, 2022) |
| Reef Divers Bonaire | 156 | (Reef Divers, n.d.) |
| VIP Diving | 199 * | (VIP Diving, 2022) |
| TDS Bonaire | 165 | (TDS Bonaire, n.d.) |
| Dive Diva Bonaire | 199 * | (Dive Diva Bonaire, 2022) |
| Toucan Diving | 175 | (Toucan Diving, n.d.) |
| Dive Friends Bonaire | 174 | (Dive Friends, n.d.) |

### 5.6. Popularity of the Specialty Course

When asked about the popularity of the course, opinions diverge. The number of courses taught depends on the size of the dive operator and whether they have sufficient instructors capable of teaching the specialty (Respondent #6, 2022; Respondent #9, 2022). Few respondents (N=5) do not regard the course to be very popular when compared to other specialty courses (Respondent #6, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #17, 2022). **Discover Scuba Diving** and **Open Water Diver** are the two courses taught most frequently on the island (Respondent #6, 2022; Respondent #9, 2022). In 2021, respondent #6 mentions to have taught four people in total (2008). Respondent #14 agrees on the fact that the Lionfish Hunter Specialty is currently not as popular as the other specialty courses, however, does experience for the course to have gained in popularity over the years (2022). Others (N=2) stated for the Lionfish Hunter Specialty to be on the same level of popularity as that of other specialties (Respondent #15, 2022; Respondent #16, 2022). The majority of the respondents (N=6), state for the course to be the most popular specialty at the time the fieldwork was conducted. Respondent #11, as a small dive operator, mentioned for them to teach between ten to fifteen lionfish courses per month (2022). The contrasting opinions of respondents are depicted below in **Figure 10**.

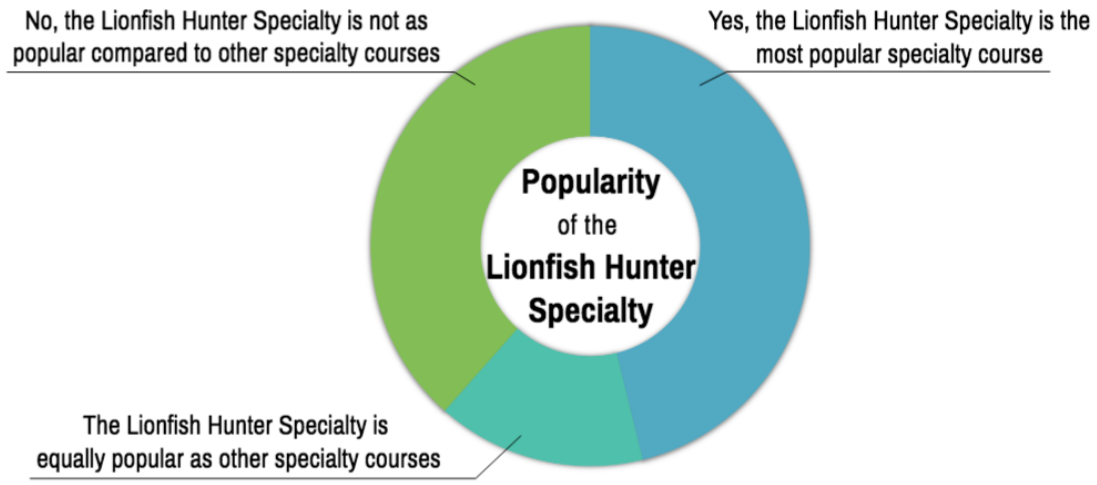


**Figure 10**. Respondents' (N=13) response to the following question: *is the Lionfish Hunter Specialty to be considered popular, compared to other specialty courses?*

# 6. Specialty Course Further Explained by Application of SPT

## 6.1. Competences

### *Competences Lionfish Hunting*

The Lionfish Hunter Specialty course carries with it certain competences required that are distinct from other specialties. The development of various skills and understanding of particular principles may aid the diver in becoming a competent lionfish hunter. These competences are developed over time and come with experience (Respondent #8, 2022; Respondent# 9, 2022; Respondent #10, 2022; Respondent #17, 2022).

The most frequently mentioned skill (N=10) involves **buoyancy** and **trim** (*See **Fig. 11***). Maintaining neutral buoyancy and correct trim helps to avoid missing the target, contact with any flora and fauna, and touching the seabed. Respondent #10 suggested using as little weight as possible to assist with buoyancy control and trim (2022).

Secondly, respondents mentioned (N=7) **air management**, **time management** and other routinised principles that fall under these, to be particularly aware of. Hunting creates certain psychological effects that in turn result in various physical effects such as divers holding their breath (Respondent #10, 2022). Feelings of excitement may release adrenaline, which could cause divers to experience an increased heart rate followed by rapid and irregular breathing (Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #17, 2022; Respondent #19, 2022). To avoid this, the principles of calmness and relaxation are stressed in order to control the breathing. Divers are advised to perform regular check-ups of their dive time, air consumption, and depth on their dive computers and to make sure to avoid any decompression stops.

Knowing how to handle and shoot with an ELF involves a special technique (Respondent #9, 2022). It furthermore requires a certain amount of physical strength to be able to pull back the spring and activate the trigger system (Respondent #7, 2022). Another competency widely mentioned (N=7) focuses on correct **aim**. Preferably, a lionfish hunter should aim for an instant kill shot, avoid missing the target, and hitting any reef structures. If the fish is not killed instantly, the diver should follow through by stabbing its brain to avoid the fish to wiggle off the ELF and getting stung. Furthermore, in order to avoid missing the target that allows for the lionfish to swim away, the diver should always try to aim correctly and be decisive. Whenever a diver cannot expect a clean shot, refrain from shooting.

**Figure 11**. Generally, the desired trim is a natural horizontal swimming position

Furthermore, the development of **situational awareness** was recommended (N=4) to any successful lionfish hunter (Respondent #8, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #17, 2022). This includes spotting the lionfish, which are prone to stay hidden, sit in crevices or near coral or other reef structures (Respondent #8, 2022). Moreover, one should always be aware of the surrounding area, perform regular buddy checks and beware of predatory fauna, with in particular, green moray eels. Respondent #11 suggested that when being chased by a moray eel, the diver should release the Zookeeper and swim away from the reef into the open ocean, whilst staying at the same depth (2022).

**Underwater magnification** is another principle discussed by respondents (N=3) that a diver should be aware of. Especially due to the interactive nature of hunting lionfish, divers need to understand that objects appear larger and closer under water (Respondent #9, 2022; Respondent #10, 2022; Respondent #12, 2022).

Lastly, **safe fish handling** was mentioned (N=3). Cleaning the lionfish by gutting and de-spining prepares the fish for consumption (*See **Fig. 12**, **13**, **14**, **15** and **16***). The advice is to undertake these practices on land to avoid attracting predators, save on air, and minimise getting stung (Respondent #15, 2022). In case a diver does get stung, respondents mentioned the importance of knowing how to apply first aid; how to treat a lionfish sting and to avoid over-reacting when under water (Respondent #12, 2022; Respondent #15, 2022; Respondent #19). On the following page, **Table 6** provides an overview of the competences necessary for lionfish hunting, specified by the respondents.

**Figures 12, 13, 14 ↑, 15, 16 ↓**. From De-spined Lionfish to Lionfish Ceviche

**Table 6**. Lionfish Hunting Competences

| Competency | Notes & Citations | Respondent (no.) |
|---|---|---|
| Buoyancy & Trim | • How to properly weight yourself: use as little weight as possible (Respondent #10, 2022) | 6, 8, 10, 11, 12, 15, 16, 17, 18, 19 |
| Air Management & Time Management | • ''General control of diving. […] Keep your bottom time. Keep your depth, keep control over everything'' (Respondent #18, 2022) | 7, 8, 10, 12, 17, 18, 19 |
| Aiming | • ''If you hit it, you have to hit it in the in the sweet spot because they will wiggle off your ELF'' (Respondent #8, 2022) | 8, 9, 10, 11, 12, 17, 19 |
| Situational Awareness | • ''If you get chased by a green moray eel, […] stay the same depth, but you swim […] into sea because the moray eels, they're scared of swimming far from the reef. So, they will turn around at some point'' (Respondent #11, 2022) | 10, 11, 17 |
| Underwater Magnification | • ''When thinking to be at a certain distance, divers need to get just that much closer to the fish, without spooking it'' (Respondent #10, 2022) | 9, 10, 12 |
| Safe Fish Handling | • ''You have to be calm and you have to […] be careful as well. Very careful. […] Because […] it's easy to get stung'' (Respondent #12, 2022)<br>• ''You must have the wherewithal to not overreact at this sting. I don't know of a lionfish sting killing somebody. But I know of people dying because of a lionfish sting'' (Respondent #19, 2022) | 12, 15, 19 |

Apart from the Lionfish Hunter Specialty, there are additional courses that complement the diving skills necessary to become a competent lionfish hunter. Paragraph **2.2. Specialty Course Requirements**, stated the following courses to be recommended prior to enrolling in the Lionfish Hunter Specialty: **Certified Advanced Open Water Diver** and **Enriched Air Certified Nitrox**. Besides these two courses, respondents furthermore mentioned a **Technical Diving Course** as well as a **Rebreather Program**, which will allow for the diver to move through the water more quietly, go deeper, and stay out for longer (Respondent #8, 2022; Respondent #12, 2022; Respondent #17). A list of the additional specialty courses is provided below, in Textbox 4.

**Additional Specialty Courses:**
- Certified Advanced Open Water Diver
- Enriched Air Certified Nitrox
- Technical Diving Certification
- Rebreather Diver Course

**Textbox 4.** Useful courses that may support a diver's lionfish hunting abilities

## 6.2. Materials

### *Participants of the Specialty Course*

In general, this specialty follows the same rules applied to all PADI courses, which means people from the age of fifteen years and up are allowed to participate (PADI, n.d.). Respondent #7 mentioned that ''elderly females'' nowadays seem to show interest in following the course (2022), implying that this specialty attracts people from all ages. The participants that engage in the Lionfish Hunter Specialty course on Bonaire include a mixture of **tourists** and **residents** (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). The residents can be further sub-divided by local divers, resident' friends and family, expats, and the STINAPA Junior Rangers (Respondent #12, 2022; Respondent #14, 2022; Respondent #15, 2022). This group is most likely to become active lionfish hunters after having obtained certification (Respondent #6, 2022; Respondent #7, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #18, 2022).

Although residents engage in the specialty course, respondents stated for the tourists to form the vast majority participating in this course (Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #17, 2022; Respondent #18, 2022). Needless to say, the residents need to engage in this specialty only once where after they are allowed to hunt on their own. This is the reason for most participants of the course being tourists. One respondent provided an estimation of tourists consisting of 80% of the total customer base, whereas the remaining 20% would be the residents (Respondent #11, 2022). Respondent #9 mentioned 40% of tourists coming from the USA, 40% are from the Netherlands, and the remaining 20% includes tourists from the UK, Belgium, Germany and Canada (2022). Most tourists that follow this specialty course do not become active lionfish hunters after certification (Respondent #6, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #17, 2022). As previously stated, tourists do not have the option of becoming active lionfish hunters after certification because they are not allowed to purchase a spear and hunt on their own (Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022). Respondents mentioned for this to be a contributing factor that forms a barrier to participation (Respondent #7, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #17, 2022). Moreover, tourists lack the time to become experienced lionfish hunters for their vacation only lasts for so long (Respondent #18, 2022). Few dive operators do, however, report returning visitors to participate in guided lionfish-hunting dives after having obtained certification (Respondent #10, 2022; Respondent #14, 2022; Respondent #16, 2022).

Lastly, as mentioned by respondent #15, the divers that belong to the target group of this specialty course, can be subdivided amongst two type of divers (2022): I) the more adventurous / ''macho'' diver, and II) the more ''feminine'' reef-oriented / conservation diver. On the following page, **Figure 17** depicts the general participant profile that follows the specialty course.

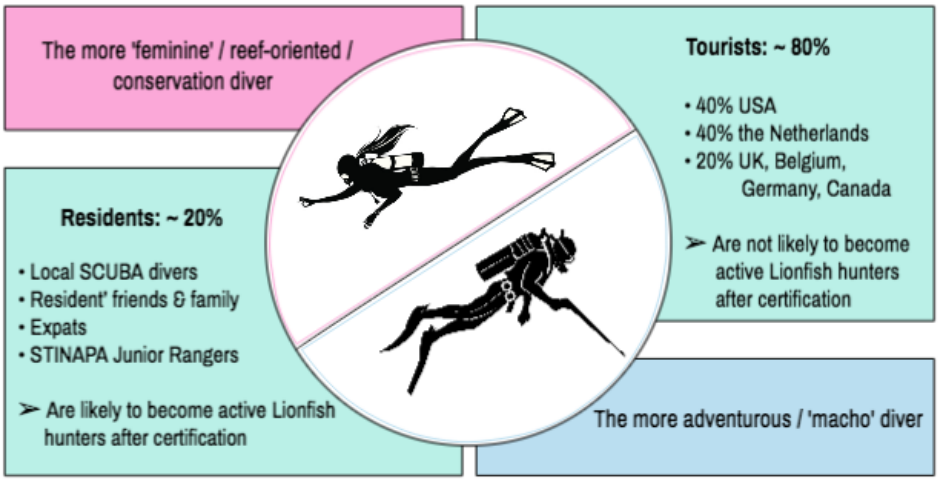


**Figure 17**. Participant Profile of the PADI Distinctive Specialty Course: Lionfish Hunter on Bonaire

### *Number of Lionfish Caught During the Specialty Course*

Respondents have mentioned for the number of lionfish caught to be dependent on many unknown factors and is thus prone to change (Respondent #15, 2022; Respondent #16, 2022; Respondent #19, 2022). On average, **three** lionfish are caught while teaching the specialty course. Respondent #10 mentioned for the first dive to follow a certain learning curve, and that most participants will shoot more lionfish during a second hunting dive (2022). The number of lionfish caught also depends on other factors. There is a higher change of catching a larger volume when hunting at different times of day, when the lionfish do their own hunting at dusk and dawn (Respondent #10, 2022; Respondent #19, 2022). **Table 7** below provides an overview of the number of lionfish caught during the course, in comparison to the number of lionfish caught outside the course.

**Table 7**. Number of Lionfish Caught During Hunting

| No. of Lionfish Caught During the Specialty Course | No. of Lionfish Caught During a Guided Dive | Resident Hunting Dive No. of Lionfish Caught | Respondent (no.) |
|---|---|---|---|
| 2/3 | 10 | 20/72/111 | 7 |
| Up to 6 | - | - | 9 |
| Above average 4/5<br>Below average 1/2 | Morning dive 6/8/12<br>Evening dive 30/40 | - | 10 |
| 8 | - | - | 11 |
| 1/2 | - | 8/9 | 12 |
| 4/6 | - | - | 14 |
| 1/2 | - | - | 15 |
| 1 | - | - | 16 |
| 2 | - | - | 17 |
| 2/3 | - | - | 18 |
| - | - | 160 | 19 |
| **3** | | | |

### *Course Locations*

During the course, dive operators and instructors will typically ask around to see whether there have been any lionfish spotted and will then hunt at those locations (Respondent #12, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #18, 2022). All known and officially marked dive sites are included within this list (Respondent #19, 2022). Most lionfish hunting will take place on the leeward side of the island, however, also includes the East Coast (Respondent #7, 2022; Respondent #12, 2022). Respondents furthermore mentioned 'advanced dive sites', 'areas where few people hunt', 'unmarked and inaccessible dive sites', 'dive sites that require access from a boat', and the dive sites at Klein Bonaire (Respondent #7, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #16, 2022; Respondent #19, 2022). Moreover, the marine reserves that are normally not accessible to divers are periodically opened for volunteers and BNMP staff to allow for lionfish culling (Respondent #1, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #19, 2022). A visual representation of the hunting locations is given below in **Figure 18** and marks the dive sites visited by tourists as well as resident hunters. The areas visited include shore diving locations of all the officially known dive sites. Although mentioned by two respondents, no distinct dive locations at the East Coast were mentioned and were thus not included in this map. In addition to **Figure 18**, **Table 8** provides an overview of the dive sites specifically mentioned per respondent. **Figure 18** depicts the map of lionfish-hunting dive sites in Bonaire mentioned by respondents, marked by locations visited either during or outside the course. Green implying the lionfish-hunting dive sites that are visited outside the course. The dive sites highlighted in pink include areas that tourists are allowed to participate in, whereas blue implies both groups.


**Figure 18**. Lionfish-Hunting Dive Sites Map Bonaire

**Table 8**. Lionfish-Hunting Dive Sites in Bonaire

| Lionfish-Hunting Dive Site | Respondent (no.) | Dive Site Visited During the Specialty Course | Dive Site Visited Outside the Specialty Course | Location Unknown |
|---|---|---|---|---|
| Klein Bonaire | 7, 8, 10, 15 | | | |
| 4WheelDiving House Reef | 11 | | | |
| VIP House Reef Sebastian's Reef | 15 | | | |
| Corporal Meiss | 17 | | | |
| 'Advanced dive sites' / 'difficult to access' / 'unpopular dive sites' / 'remote locations' / 'unmarked dive sites' | 9, 12, 16, 10 | | | |
| A dive site recommendation reported by someone having spotted a Lionfish in the last 24 hours | 12, 14, 15, 18 | | | |
| 'Dive sites from a boat of view' / 'a spot that is difficult to access from shore' | 10 | | | |
| 'Advanced dive sites' / 'unpopular dive sites' / Marine Reserves / No-diving areas | 1, 7, 8, 11, 12, 19 | | | |
| BOPEC | 1, 7, 8, 11 | | | |
| Karpata | 7, 11, 9 | | | |
| East Coast | 7, 12 | | | |
| Willem Alexander Marine Park | 1, 8 | | | |
| Candy Land | 8 | | | |
| Windjammer | 8 | | | |
| Hilma Hooker | 12 | | | |
| 'Between Something Special and Salt Pier' | 13 | | | |
| Harbour Village | 13 | | | |
| Washington Park | 19 | | | |
| Small Wall | 19 | | | |
| 'All of the named sites we dive on a regular basis' | 19 | | | |

### *Equipment*

As with regular scuba diving, engaging in a Lionfish Hunter Specialty course requires a collection of materials. The equipment can be subdivided into items needed *before*, *during*, and *after* engagement of the practice.

A formality that should be taken care of prior to any aquatic activity and, in particular, scuba diving, is to purchase a **Marine Park Tag** via STINAPA and pay an admission fee of 45 USD (Respondent #9, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #18, 2022). The tourist pays the fee online and receives an E-tag, which can be procured as a physical tag at the STINAPA headquarters. The scuba diver is expected to carry this tag along during their diving activities or be able to show the E-tag when asked. In the past, tourists were able to buy their tags at local dive shops, where the staff would provide them with an explanation concerning the marine park rules and regulations (Respondent #12, 2022; Respondent #18, 2022).

Needless to say, during a dive the lionfish hunter is expected to wear **standard dive gear**, either personally owned or hired (Respondent #6, 2022; Respondent #17, 2022). Next, the tool most frequently mentioned (N=17), that distinguishes this specialty from other diving practices is called the **ELF**. The ELF is an acronym for Eliminate Lionfish (Respondent #9, 2022; Respondent #10, 2022; Respondent #15, 2022; Respondent #17, 2022), and was introduced to Bonaire as a modified spear, since other type of pole spears such as the Hawaiian sling and other spearguns are prohibited on the island (Respondent #2, 2022; Respondent #5, 2022; Respondent #6, 2022, Respondent #8, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #17, 2022; Respondent #19,

2022). Residents are allowed to apply for an ELF after a deposit is paid of 150 USD (Respondent #11, 2022). The required application form is shown in **Appendix 4**. Afterwards, STINAPA will issue the ELF tool along with its corresponding serial number.

In the earlier days of the invasion in 2009, divers used nets, bags, and bottles to catch the lionfish (Respondent #2, 2022; Respondent #10, 2022; Respondent #13, 2022). The lionfish were very small, about an inch, during the first year (Respondent #13, 2022). After one year the lionfish grew bigger to about 4/ 5/ 6 inches, so within one year it became impossible to continue to use small nets and bags (Respondent #19, 2022). Meanwhile in Cozumel, Mexico, Bixby constructed the first prototype where the tool was made out of old bicycle parts (Respondent #19, 2022). This simple tool was a plastic pipe containing a thin wire made out of iron, designed to shoot lionfish of about 3 to 4 inches long, and killed the fish upon impact (Respondent #2, 2022; Respondent #19, 2022).

*''Then the fish grew. As the fish grew, the diameter of that piece of wire grew. And the fish grew more so we put threads on that piece of wire, grooves, so that the fish couldn't slide off as easy. The fish grew more so we put a three-prong tip on it: a paralyzer tip. The fish grew more so everything just continued to get larger until we're at the point we are now''*
(Respondent #19, 2022)

When the ELF got introduced to Bonaire it lacked a certain trigger system (*See **Fig. 19***). Respondent #13 puts forward the analogy of comparing a regular bow and arrow to a crossbow. A crossbow is to be pulled back and the mechanism allows the user to wait and shoot when ready. Whereas with a bow and arrow, one has to rely on physical strength and hold on until they are ready to shoot. The ELFs cannot be flown into Bonaire with a trigger system, for that would make them against the law (Respondent #19, 2022). The ELFs need to be assembled on the island where Tol installs the trigger and is still the main contact point today in case the tool needs any repairs (Respondent #7, 2022; Respondent #13, 2022; Respondent #19, 2022).

The latest version of the ELF tool (*See **Fig. 20***) has a total length of 73 to 75 centimetres, a 6-millimetre shaft with a range of 8 inches (Respondent #7, 2022; Respondent #19, 2022). The intentional design of the spear was a way of monitoring the divers' activities. One of the qualities of a short spring combined with a short range is that the ELFs allow for more control as to which species of fish the people will be hunting (Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #10, 2022; Respondent #14, 2022; Respondent #17, 2022; Respondent #19, 2022). This makes it easier for law enforcement, so that divers are only able to catch what the acronym stands for. Furthermore, not only does the ELF make it more difficult to injure another diver (Respondent #19, 2022), it is also harder to damage the coral reef (Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #10, 2022; Respondent #19, 2022).

**Figure 19**. ELF Prototype (Spearfishing World, n.d.)

**Figure 20**. Lionfish and ELFs (Fernández Gutiérrez, 2022)

Another widely mentioned piece of equipment pivotal to this specialty (N=12) is called a **Zookeeper**. The Zookeeper evolved alongside the ELF and at one point used to be the same thing (*See **Fig. 21, 22 and 23***). At the beginning of the lionfish invasion when the fish were small enough to catch using little nets or bags, the method of collection also served as containment unit (Respondent #2, 2022; Respondent #13, 2022; Respondent #18, 2022). Using this method to catch lionfish, it used to be common for divers to get stung (Respondent #2, 2022; Respondent #3, 2022; Respondent #13, 2022). As the fish grew larger, people started to either make their own containment units by placing funnels inside buckets, or made use of wet bags (Respondent #2, 2022; Respondent #10, 2022). Concurrently, there was a gentleman from overseas that created the Zookeeper, got it patented, and was now introduced to Bonaire in 2012 (Respondent #2, 2022; Respondent 10, 2022). Essentially, the Zookeeper is a large PVC pipe with an added funnel, amongst other modifications (Respondent #15, 2022). Present-day, one can either buy a Zookeeper online and have it shipped to Bonaire, get a customised Zookeeper made by Tol, or make one themselves (Respondent #11, 2022; Respondent #14, 2022; Respondent #17, 2022).


**Figures 21, 22, 23**. From Net to Bag (Respondent #2, personal communication, July 25, 2022) to Zookeeper (Fernández Gutiérrez, 2022)

Besides the ELF and Zookeeper, a lionfish hunter carries with them other standardised equipment that may differ from the materials used during other types of scuba activities. Respondent #15 suggested to always carry a **flashlight** (*See **Fig. 24***), which can be useful for looking into holes and other type of formations (2022). Furthermore, respondents mentioned that a **dive knife** (*See **Fig. 25***) or other type of long tool such as a **barbecue fork** might come in handy to transfer the lionfish off the ELF and help place it into the Zookeeper (Respondent #10, 2022; Respondent #15, 2022; Respondent #17, 2022). This tool might also be used to deliver the final blow that will instantly kill the fish. Instead of using a dive knife, respondent #11 suggested using another ELF (2022). Lastly, respondent #19 recommended carrying **two dive computers** in case one fails (2022). The main reason for this was stated in an earlier paragraph, namely, to avoid any decompression stops.


**Figure 24**. Flashlights and Zookeeper STINAPA

**Figure 25**. Dive Knife

After a hunting dive is complete, respondents referred to any **cutting tools to clean and fillet** the lionfish to prepare them for consumption. In order to handle the fish safely, one can choose to wear **piercing-protecting gloves** and use **scissors** or other sharp **shears** to de-spine the fish (Respondent #14, 2022; Respondent #16, 2022). Gutting the fish can be accomplished easily with the help of **pliers** (Respondent #11, 2022; Respondent #15, 2022).

Lastly, another piece of equipment that might turn out to be useful during a lionfish hunting dive, forms part of the first-aid kit. In case of a lionfish sting, respondent #16 suggested to make sure to bring **hot water in a thermos bottle**, which can be placed inside the car or anywhere near the dive spot (2022). As an alternative, respondent #2 mentioned to make use of **reusable hand warmers** that give off heat (2022).

### *The Lionfish and Their Evolution on Bonaire*

Probably the most important tangible object of the Lionfish Hunter Specialty course, that initiated the practice in the first place, would be the lionfish itself. This chapter will touch on size, abundance, density and distribution of the lionfish as well as any changes in lionfish behaviour towards divers and, in particular, lionfish hunters.

On Bonaire, the first lionfish sighting, or the first time someone spotted and collected a lionfish was in October 26, 2009, by Ramón de León (*See **Fig. 26***), who was the former Marine Park Manager of STINAPA (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022, Respondent #18, 2022). During the first year of the lionfish invasion, between 2009 and 2010, the lionfish were all relatively small and were all about the same size of around one inch in length (Respondent #13, 2022). After one year, the lionfish grew bigger to about 4/ 5/ 6 inches (Respondent #19, 2022). The body size kept growing larger until they reached the present-day size. Fast forward to 2022, the lionfish that were caught most frequently had a body length that averaged around 10-15 centimetres, whereas larger ones could reach lengths to around 36-43 centimetres (Respondent #10, 2022).

A couple of years into the invasion, respondents experienced that the lionfish reached the peak of their density and distribution. Respondents mentioned that between 2012 and 2015, divers encountered them everywhere, within the confines of recreational diving depths (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #16, 2022; Respondent #18, 2022). Moreover, respondents stated that it used to be relatively easy to hunt and kill the lionfish (Respondent# 1, 2022; Respondent #3, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent 14, 2022; Respondent #16, 2022; Respondent #18, 2022). This was not only because the lionfish were more abundant in shallower waters, but also because the lionfish did not shy away from scuba divers. Some respondents suggested this having to do with the fact that in the beginning, it was easier to shoot the lionfish because they were not used to being hunted (Respondent #1, 2022; Respondent #8, 2022; Respondent #14, 2022).

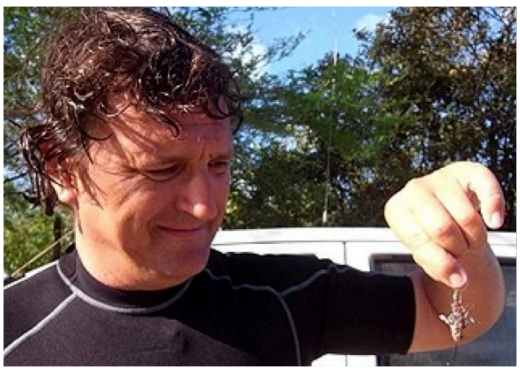

**Figure 26**. Ramón de León with the first spotted and caught lionfish on Bonaire (Respondent #2, personal communication, July 25, 2022)

At the time of fieldwork in 2022, respondents reported a drop in lionfish density or abundance within shallow waters that are within recreational diving depths (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #16, 2022; Respondent #18, 2022). Furthermore, respondents noticed several changes in lionfish behaviour towards scuba divers and, in particular, towards lionfish hunters (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #17, 2022; Respondent #19, 2022). The majority of respondents (N=11) mentioned that the lionfish have the ability to learn from past experiences and adjust their behaviour accordingly. Lionfish that got shot at but managed to survive have now become wary of divers and shy away from them in future interactions (Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #19, 2022). According to respondents #13 and #19, a lionfish that has never been shot at will not move around and try to hide from its shooter (2022). The lionfish were reported to respond to the sound and sight of bubbles exhaled by scuba divers (Respondent #1, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #19), and tend to swim away fast because of this. Others have mentioned the mere sight of a diver (Respondent #12, 2022; Respondent #15, 2022) shies them away, as well as the use of flashlights and the sound and sight of the ELF (Respondent #6, 2022; Respondent #13, 2022; Respondent #17, 2022). All of these signs that mark the presence of a lionfish hunter make for the lionfish to hide away in reef structures (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022). Few respondents (N=4) have stated for all the lionfish to have changed their behaviour towards divers, meaning not merely the fish that got shot at (Respondent #3, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #18, 2022). Respondent #14 mentioned that the lionfish might be able to communicate to others when they sense being in danger, and respondent #12 proposed that the lionfish may be able to pass on this information unto their offspring (2022).

When discussing the topic of lionfish distribution, opinions diverge. Where some stated (N=3) that ever since humans started hunting lionfish, they have now resided more towards deeper waters (Respondent #1, 2022; Respondent #3, 2022; Respondent #14, 2022). Others (N=3) have mentioned that the lionfish have not moved to deeper waters, rather, the lionfish have always been there since the start of their introduction (Respondent #2, 2022; Respondent #7, 2022; Respondent #19, 2022). Lionfish are known to reach depths beyond 200/ 300/ 400 feet (Respondent #10, 2022; Respondent #11, 2022; Respondent #13, 2022) and have even been spotted down to 600 feet, observed by a submarine of the Smithsonian Institute (Respondent #1, 2022). Respondents mentioned that around these depths, the exceptionally large lionfish gather (Respondent #1, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15 2022). Respondents #1 and #3 speculate for these large fish to probably hide away from lionfish hunters (2022). Respondent #1 stated they would only come up to feed and would then go back down again (2022).

The most common depth to find lionfish, as mentioned by respondent #10, is between the 60- and 80-feet mark (2022). Many respondents stated (N=7) for the lionfish to be more abundant in deeper waters opposed to the shallow waters (Respondent #2, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #13, 2022; Respondent #16 2022, Respondent #19, 2022). Respondents #7 and #19 provided the explanation of the reason being that these depths are simply beyond recreational diving limits, which is why the density is higher in deeper waters (2022).

*''More hunting, fewer lionfish. Less hunting, more lionfish''*
(Respondent #7, 2022)

The drop in lionfish abundance or density in shallower waters, mentioned by respondents (N=9), led to the lionfish hunters to catch their fish with relative difficulty for the fish now tend to hide and are less frequent to come by (Respondent #1, 2022; Respondent

#3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #16, 2022; Respondent #18, 2022). This is the reason respondent #8 decided to follow a technical diving course, in order to be able to meet his prey at greater depths (2022). Moreover, the lionfish that are to be found within recreational depths are generally smaller than the fish found beyond those depths (Respondent #1, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15 2022). These two factors are, according to respondent #2, signs of overfishing (2022). Namely, a lower density and individuals becoming smaller and smaller each time.

However, it cannot be declared with absolute certainty that the employed management efforts proved effective based on the statements presented in the aforementioned paragraph. Many respondents agree (N=8) on the fact that the lionfish density and abundance fluctuate depending on many different factors (Respondent #2, 2022; Respondent #7, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022). Respondents have mentioned that lionfish hunters will be more successful when diving at certain times of day, namely during crepuscular times, when the lionfish are doing their own hunting (Respondent #10, 2022; Respondent #11, 2022; Respondent #18, 2022; Respondent #19, 2022). Moreover, respondents #10 and #14 mentioned that the number of lionfish spotted within recreational depths also depend on the number of active lionfish hunters on the island (2022). Scuba activity in general, mentioned by respondent #19, makes for less frequent appearances of lionfish (2022). Additionally, respondent #10 mentioned changes in water temperature to affect lionfish abundance (2022). Whenever the water temperature increases there tend to be more lionfish. Further, respondent #15 mentioned seasonal fluctuations in lionfish density and respondent #2 even referred to annual fluctuations (2022).

Whether big or small, frequent or less abundant, the vast majority of respondents (N=18) stated that the lionfish will never be truly eradicated and are therefore permanent residents of Bonaire's waters and surrounding ecosystem (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #4, 2022; Respondent #5, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022).

### *Predators of the Lionfish on Bonaire*

One of the main concerns people had regarding the lionfish, and which advocates for controlling their numbers by means of human intervention, is due to the lack of natural predators for the relatively newly introduced species (Respondent #1, 2022; Respondent #7, 2022; Respondent #9, 2022; Respondent #11, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022).

> *''It's not native here. […] It was never here in [sic] 4.6 billion years and then it arrived in 2000. And it's clear where [sic] it came from. […] It's an invasive'' species.*
> (Respondent #3, 2022)

Respondents (N=6) have attributed human doings for the introduction of the lionfish into the Atlantic Ocean (Respondent #2, 2022; Respondent #3, 2022; Respondent #10, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022). Besides the fact that the lionfish lacked any native predators in the Caribbean, Bonaire's waters in general lacks the presence or volume of apex and medium sized predators such as large groupers or sharks (Respondent #2, 2022; Respondent #7, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #15, 2022; Respondent #17, 2022; Respondent #18, 2022). Respondent #2 reported that predatory species like groupers have been in historical decline, and respondent #18 mentioned that around 2007/2008

a disease amongst the moray eels circulated that caused for a huge population die off that has yet to be recovered (2022).

In consequence of the lionfish lacking natural predators in Caribbean waters, divers have taken it upon themselves to hunt down these invasive fish (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #10, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022). Aside from the humans taking on the role of predator species, divers furthermore attempted to intervene underwater by trying to feed dead or injured lionfish to large moray eels, so they would develop a taste for them (Respondent #1, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #17, 2022). This practice later ceased because it induced behavioural changes in the moray eels towards divers (Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #17, 2022). The large green and spotted moray eels started to associate scuba divers with food. The eels would chase them down trying to attack them and even climb into Zookeepers. Although the intentional feeding has stopped ever since the accidents happened, divers do still pull apart dead lionfish that are not brought back for consumption and leave them in the water so other species still get the chance of eating them (Respondent #7, 2022; Respondent #9, 2022; Respondent #14, 2022; Respondent #15, 2022). Respondent #13 reported pulling the small lionfish apart in the same manner, and then feeding them to anemones (2022).

Despite the lionfish lacking any native predators in the Caribbean, respondents did mention that, whether induced by human intervention or not, different species of fish have started to become rather inquisitive by lionfish and some have even reported to notice a shift in predator-prey dynamics.

The predatory species showing interest in lionfish that respondents have stated most commonly (N=14) include groupers, snappers, moray eels and even sharks (Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). What the respondents do emphasize, however, is that these species would only go after already dead or injured lionfish.

The predatory species most frequently mentioned (N=10) are the moray eels (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #13, 2022; Respondent #19, 2022), of which green moray eels (Respondent #10, 2022; Respondent #12, 2022) and spotted moray eels (Respondent #17, 2022) in particular showing aggressive behaviour towards human lionfish hunters. Furthermore, respondents (N=2) mentioned for them to showcase territorial behaviour, in the sense that they are trying to protect any lionfish near them, in case a diver with an ELF is trying to collect the fish (Respondent #13, 2022; Respondent #19, 2022). Others (N=2) stated that the green moray eels will not attack living lionfish and will only do so when the fish display certain movements of distress or are already injured (Respondent #10, 2022; Respondent #12, 2022). Few respondents (N=2) have, however, reported observing green moray eels attack and consume a living lionfish before the divers ever got the chance to spear them (Respondent #10, 2022; Respondent #18, 2022). Respondent #7 added to this by stating that it might already be happening, although no humans are around to observe this phenomenon (2022).

While there have been reports of large groupers consuming lionfish (Respondent #7, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #14, 2022; Respondent #19, 2022), it does not happen as often for these fish lack great numbers. Various types of snappers were reported to grab off lionfish from spears and were thus labelled to having reached an intermediate stage (Respondent #7, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #16, 2022; Respondent #19, 2022). Meaning, they are starting to understand the lionfish to be a food

source. Amongst these snappers are included yellowtail snapper and grey snapper (Respondent #10, 2022; Respondent #19, 2022).

Other species of fish that respondents have seen, not by means of personal observation but through video, predating on the lionfish in Bonaire include barracuda (Respondent #1, 2022) and frogfish (Respondent #19, 2022). Additionally, stomach content analysis revealed other lionfish inside their stomach, which is probably what they consume in deeper waters when there are less fish for them to eat (Respondents #13, 2022; Respondents #19, 2022). Finally, amongst the current predators of the lionfish on Bonaire are included the human lionfish hunters (*See **Fig. 27***) (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #10, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022), as well as diseases (Respondent #15, 2022) that seem to contribute to diminishing their numbers.


**Figure 27**. Posing with ELF and Zookeeper while tourist in the background is hunting on Nitrox

## 6. 3. Meanings

### *Human Involvement in Invasive Species Control*

As previously mentioned, respondents engage in hunting lionfish because Bonaire's waters lack the volume of large predatory species, and thus take it upon themselves to do so (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022). The majority of respondents (N=17) have stated that human efforts are an absolute necessity when it comes to controlling the lionfish density (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). Out of these respondents, few (N=2) have expressed that human efforts are less of a necessity but are rather a supportive action (Respondent #11, 2022; Respondent #17, 2022). Some respondents (N=6) feel it is their duty to assist by actively culling lionfish, so that nature can slowly adapt to their presence, until the ecosystem has reached a state of equilibrium where human involvement is no longer necessary (Respondent #3, 2022; Respondent #7, 2022; Respondent #11, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022). A minority of respondents (N=2), although having expressed more residents to feel this way, stated that they refuse to believe human control efforts are necessary (Respondent #4, 2022; Respondent #5, 2022). They furthermore mention that humans cannot control nature, that the lionfish poses no threat to the island's ecosystem and are in fact already part of it.

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In this moment, however, the majority of respondents opt for human control efforts being necessary. On the occasion of no human control efforts, respondents (N=14) believe that the lionfish density will increase up to a point where they take over the reef, become the primary predatory species, consume all native reef fish, and finally, disrupt the wider ecosystem (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19). The source of these concerns points to other Caribbean reefs and beyond. Respondents stated they do not want Bonaire to follow in the footsteps of places such as Florida and The Bahamas (Respondent #8, 2022; Respondent #9, 2022; Respondent #11, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #17, 2022; Respondent #19, 2022). On the following page, **Figure 28** shows a somewhat out-dated graph, but depicts the lionfish density of Bonaire in comparison to other islands in the Caribbean, as provided by STINAPA.

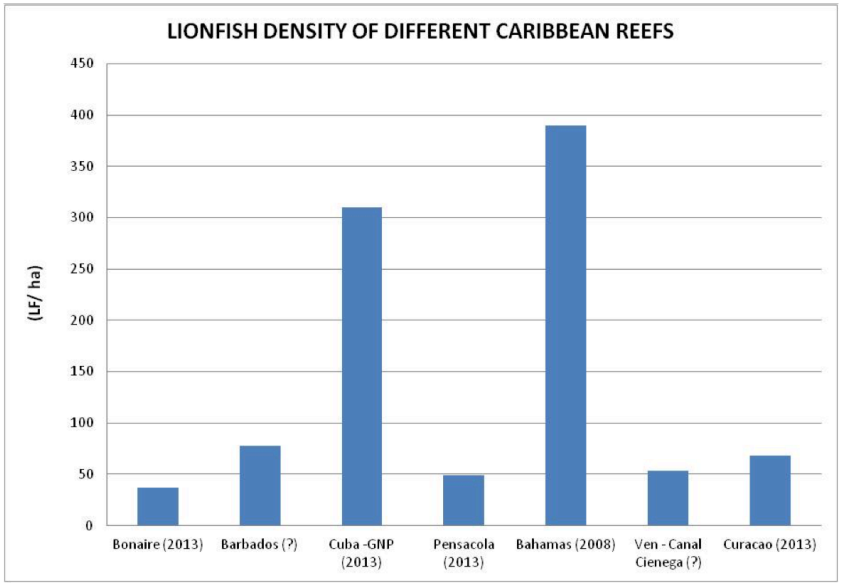


**Figure 28**. Lionfish density of Bonaire and other islands in the Caribbean (Respondent #2, personal communication, July 25, 2022)

Back in 2011, Respondent #2 stated that the neighbouring island of Curaçao suffered three times the lionfish density compared to Bonaire (2022). See **Figure 29** for an illustration that compares the lionfish density of Bonaire to that of Curaçao. For fear of Bonaire suffering from a high lionfish density as other Caribbean reefs have, it was decided for Bonaire to adopt the Precautionary Principle (Respondent #2, 2022; Respondent #9, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022).

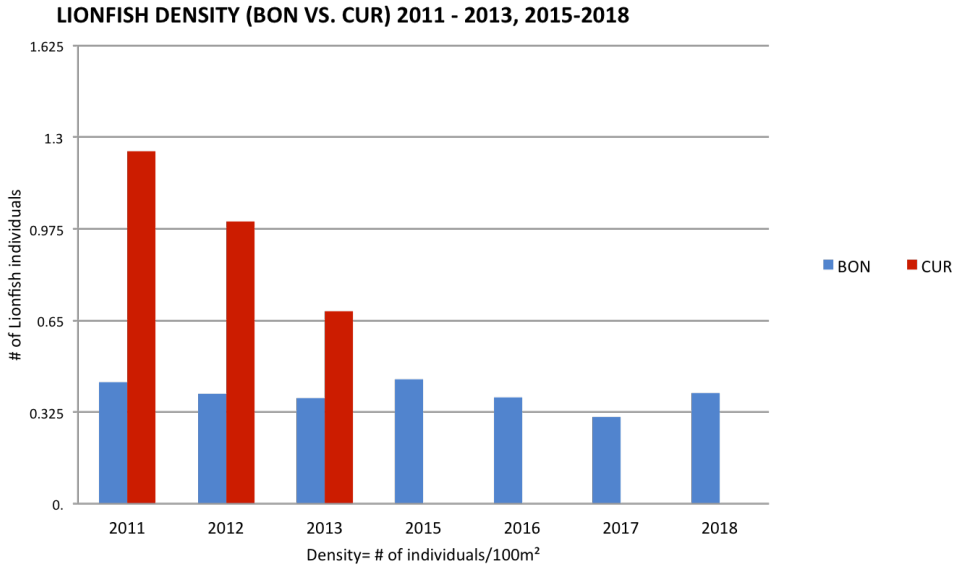


**Figure 29**. Lionfish density of Bonaire and Curaçao (Respondent #2, personal communication, July 25, 2022)

At the time of writing, respondents affirmed for the lionfish density to be in control, with numbers lower in shallower waters opposed to in deeper waters (Respondent #2, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #18, 2022; Respondent #19, 2022). The claim of the lionfish density to be in control was based on the target number set by the **National Plan determined for the wider Dutch Caribbean**, appointed by the national government, according to

STINAPA (Respondent #2, 2022). As stated in the National Plan, the target was set on a **lionfish density with numbers lower than 50 lionfish per hectare**. Respondent #2 mentioned that Bonaire realised numbers lower than the set target, every year since the international objective was put in place (2022).

The fact that lionfish numbers are stable, with an annual statistically stable lionfish density since the beginning of their introduction in 2009, respondents have attributed to the human culling efforts (Respondent #2, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #18, 2022; Respondent #19, 2022). The low lionfish density was perceived successful, and respondents #2 and #13 have ascribed this to the BNMP's intervention and management plan that was initiated prior to the first lionfish sighting in Bonaire's waters (2022).

### *Questions About STINAPA's Data: Lionfish Density and Distribution*

Aside from STINAPA's statement of the lionfish density to be statistically stable every year since 2009 until present, a distinction has been made between the *fished* areas and *unfished* areas (Respondent #2, 2022). Here, *unfished* areas refer to the marine reserves, which also function as no-diving areas. The two marine reserves include the Willem Alexander Marine Park at Karpata and the area between Boka Slagbaai and Playa Frans in Washington Slagbaai National Park. According to STINAPA, the lionfish density in the unfished areas is higher relative to the fished areas; see **Figure 30** underneath (Respondent #2, 2022; Respondent #7, 2022).

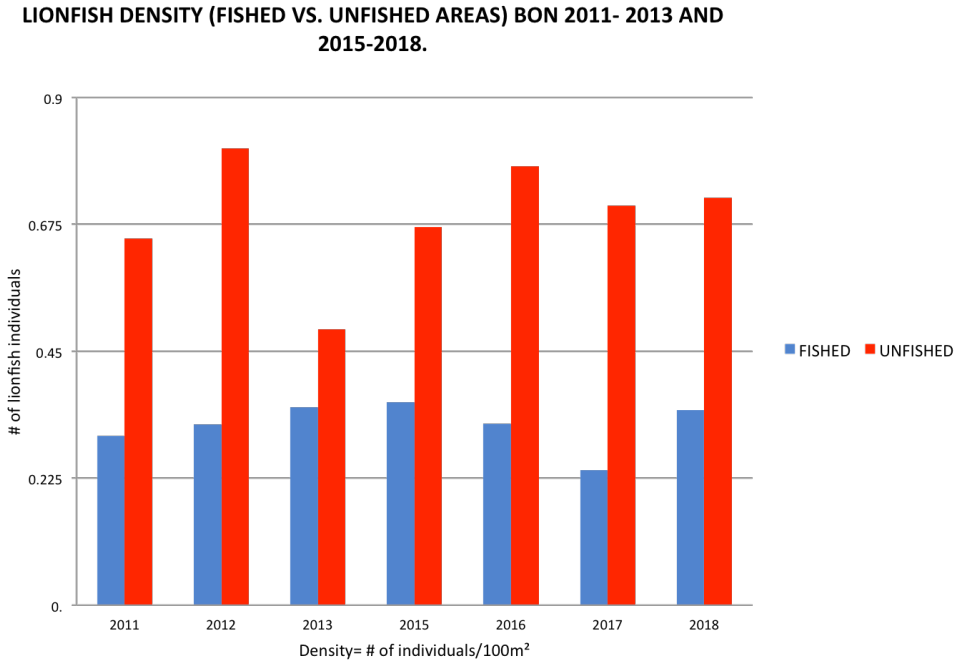


**Figure 30**. Lionfish density Bonaire in *fished* versus *unfished* areas (Respondent #2, personal communication, July 25, 2022)

Respondent #2 stated for the lionfish culling initiatives to be effective, and higher lionfish densities in the unfished areas show proof that the control works (2022). Nevertheless, although being designated as no-diving areas, respondents (N=8) mentioned that these sites still harbour people that hunt lionfish every now and then (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #19, 2022). Aside from the annual derbies that invite resident lionfish hunters to cull lionfish within the marine reserves, BNMP staff is

also permitted to hunt within these areas all year round. Furthermore, respondent #7 stated that there are some resident lionfish hunters that, although not permitted, make use of underwater scooters and hunt lionfish within these reserves (2022).

And so, although the marine reserves do in fact allow for lionfish hunting, these sites are perhaps dived less frequently compared to areas where it is allowed to scuba dive. This is the reason given to why the lionfish density is higher in *unfished* areas opposed to the *fished* areas. Nonetheless, another reason for this outcome, respondents mentioned (N=3), is because the reefs in the reserves are generally in a better condition due to less frequent human activity (Respondent #8, 2022; Respondent #12, 2022; Respondent #18, 2022). Respondent #18 stated that thanks to the general absence of human presence the reefs are in healthier condition, meaning reef fish in general are more abundant, which could also lead to a higher lionfish density due to more food being available to them (2022). No data is available whether or not native reef fish populations are lower in areas with a higher lionfish density.

As previously mentioned, following the introduction of the lionfish in 2009 respondents noticed a significant increase in lionfish abundance between 2012 and 2015, where after some years they perceived a considerable drop (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #16, 2022; Respondent #18, 2022). In recent years, respondents mentioned it is becoming increasingly difficult to find and catch lionfish in shallow waters, which points to a lower density in recreational waters when compared to previous years. Moreover, aside from the more popular dive sites, some respondents (N=3) have noticed this increased difficulty in spotting and catching lionfish to be evident as well at sites that are rather advanced, remote, or difficult to access (Respondent #8, 2022; Respondent #12, 2022; Respondent #18, 2022). The fact that there are hardly any lionfish at recreational depths nowadays, STINAPA attributes to the efforts of the active lionfish hunters that are keeping the numbers stable (Respondent #2, 2022). An interesting point raised by respondent #12, however, was that some divers (N=9) did perceive a decline in lionfish abundance (Respondent #1, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #16, 2022; Respondent #18, 2022). Subsequently, thinking that the lionfish density might have lowered after the initial increase between 2012 and 2015, which is apparently not the case since the density has been statistically stable since the start of the observation in 2011.

*''So, I was thinking that we were probably bringing those numbers down, but apparently according to STINAPA's research, we are keeping them stable. So, I don't know what's happening and I know that [...] some people say 'well, we think that the fish are going deeper, they are learning, they're becoming more intelligent, and they are going deeper' I don't know, but it's true. I don't see as many lionfish on the reefs as I used to [...] It's a good thing, but if STINAPA then says that the numbers are stable, then where are they?''*

(Respondent #12, 2022)

STINAPA stated that the lionfish density has been statistically stable since the start of the invasion, while at the same time having mentioned that they have not resided to deeper waters (Respondent #2, 2022). This perceived drop in lionfish density could perhaps be the result of more active lionfish hunters on the island in more recent years opposed to the time of the perceived increase between 2012 and 2015. During fieldwork, I did not manage to obtain any data on the number of active lionfish hunters since 2009 until present, nor the frequency of their efforts.

### *Deteriorating Coral Reefs: What Role Does the Lionfish Play?*

When posed the question whether respondents have observed any decline in native reef fish populations since the introduction of the lionfish in 2009, most (N=7) said they have not (Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #14, 2022; Respondent #17, 2022; Respondent #18, 2022). One respondent did state that temporary local reductions of species near cleaning stations seem evident when several lionfish are present near that site (Respondent #10, 2022). Once you remove those lionfish, the respondent stated, those cleaning stations come back to production line again. Coming back to the question whether there have been any declines in native reef fish populations since the introduction of the invasive lionfish, STINAPA stated that this is impossible to determine, due to lack of data on those reef fish populations prior to 2009 (Respondent #2, 2022). Further, aside from tracking the annual lionfish density at different depths and locations, no measurements are being done on native reef fish populations.

The fact that there are no noticeable declines in native reef fish populations, the majority of respondents (N=9) attributed to the active lionfish hunters, and mentioned that native reef fish populations are not given the chance to decline thanks to the continuous culling efforts (Respondent #2, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #18, 2022; Respondent #19, 2022). In general, however, native reef fish populations have been in historical decline, the coral reef deteriorating, and cannot be attributed to the invasive lionfish alone (Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18). Nor can it be measured to what extent the lionfish plays in the deterioration of the reefs, due to a myriad of factors intermingling and transforming the reefs each in their own way.

### *Factors that Cause the Reef to Deteriorate*

The factors most widely mentioned by respondents that contribute to the deterioration of the reef belong to **tourism** and **SCUBA diving** activities. Respondents mentioned general tourism (N=15), with a particular destructive form of that which includes cruise ships, yachts, and other polluting vessels (N=5). Regarding the scuba divers, general diving (N=12) was mentioned which creates excessive dive moments in the water. Respondents furthermore referred to specific types of divers, which include divers with bad buoyancy (N=4), photographers (N=5), and Lionfish Hunters (N=15).

Second, **natural causes** and **climatic events** were elements frequently mentioned by respondents. Climate change (N=4) and global warming (N=4) were mentioned, which might have led to an increase in oceanic water temperatures, leading to coral bleaching events (N=9). Furthermore, tropical storms, hurricanes and cyclones (N=9) were mentioned that caused for particular damage to coral reefs. Moreover, current flows and wind reversals (N=2) were named. As with hurricanes, respondent #7 stated that wind reversals create large destructive waves and stir up large quantities of sand and silt that cover and suffocate the corals (2022). Respondent #18 brought up the fact that contaminated water flows in with the current coming from the rivers of Venezuela and ends up in the waters surrounding Bonaire (2022).

The third most frequently mentioned group of determinants that cause the reefs to deteriorate were ascribed to **factors attributed to human influence**. The growing population and subsequent construction developments (N=14) including coastal development were stated to negatively affect the marine environment. One of the

consequences of this development leads to run-off (N=6) caused after heavy rainfall, with silt, construction dust, and sewage from septic tanks leaking into the ocean. Added to that is general pollution and debris, plastics, and medications such as antibiotics that end up in the water (Respondent #7, 2022; Respondent #12, 2022; Respondent #14, 2022). Sunscreen use (N=3) was another influence mentioned that affects the marine environment, as well as the activities needed for the large amount of import products its inhabitants and visiting tourists require (Respondent #16, 2022).

**Invasive species** were declared as potential threat to the marine environment. The lionfish (N=16) was specifically mentioned, as well as overgrazing herbivores such as goats that respondent #2 stated to cause an influx of sediments into the water due to the diminishing vegetation on the island (2022).

Other factors that influence the state of the reefs are attributed to **changes in biodiversity** and **reef fish dynamics**. A decline in parrotfish populations (N=3) may cause algae to overgrow and suffocate corals. A further decline in predatory species like groupers might also affect the reef (Respondent #2, 2022). Moreover, red algae and Sargasso (N=2) were mentioned to alter or influence the marine environment. Respondent #2 further stated that the introduction of diseases affects certain species, which happened to the sea urchins that resulted in a major die off (2022).

The harmful **fishing practices** that were mentioned include overfishing, illegal fishing, and illegal spearfishing. There some are fishermen on the island that do not make use of the moorings, but instead attach bricks to rope and throw them in the water, destroying the corals (Respondent #5, 2022).

Finally, people that neglect the rules declared by the BNMP that includes illegal swimming and touching coral for example, all play a role in the deterioration of the reef (Respondent #1, 2022; Respondent #17, 2022). See **Table 9** underneath for an overview of all the factors that may cause harm to the marine environment, according to respondents.

**Table 9**. Factors that Cause the Reef to Deteriorate on Bonaire

| Factors that Cause the Reef to Deteriorate | Respondent (no.) |
|---|---|
| Tourism | 1, 3, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 |
| ➢ Cruise ships, yachts, polluting vessels | 11, 14, 15, 16, 18 |
| SCUBA Divers | 1, 2, 7, 8, 10, 11, 12, 13, 14, 16, 17, 19 |
| ➢ Divers with bad buoyancy | 1, 6, 11, 14 |
| ➢ Photographers | 6, 8, 12, 13, 14 |
| ➢ Lionfish Hunters | 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 |
| Climate Change | 1, 11, 14, 17 |
| Global Warming | 2, 3, 12, 15 |
| ➢ Coral bleaching | 1, 3, 7, 8, 11, 13, 15, 17, 18 |
| Tropical storms, hurricanes & cyclones | 2, 7, 8, 10, 11, 12, 14, 17, 18 |
| Current flows & wind reversals | 7, 18 |
| Growing population, construction / coastal development | 1, 2, 3, 7, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 |
| ➢ Water run-off | 2, 7, 10, 12, 14, 18 |
| ➢ Pollution, plastics, sunscreen, medications | 7, 12, 14, 17 |
| Import activities | 16 |
| Invasive Species | 2, 9 |
| ➢ Lionfish | 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16 17, 18, 19 |
| ➢ Overgrazing herbivores | 2 |
| ➢ Humans | 2 |
| A decline in Parrotfish populations | 7, 12, 15 |

| | |
|---|---|
| Red algae & Sargasso<br>A decline in Groupers | 2, 11<br>2 |
| Fishing Practices<br>➢ Overfishing<br>➢ Illegal fishing<br>➢ Illegal spearfishing | 1<br>2, 3<br>5<br>1 |
| Disregard for BNMP rules<br>➢ Illegal swimming<br>➢ Touching corals | <br>1<br>17 |

After having comprised this list with the help of my respondents, it was curious to see that the factors of *Tourism*, *Lionfish*, and *Lionfish Hunters* were amongst the most frequently mentioned determinants for the state of the reef. These elements were all relevant to this thesis and were therefore selected for further analysis.

### *Respondent Perceptions of the Lionfish*

The practice of engaging in a Lionfish Hunter Specialty course was initiated as part of the BNMP's invasive species management and control plan. Hence, how the lionfish is perceived is of great influence to managing this invasive species. The following word cloud (*See **Fig. 31***) provides a collection of the words, thoughts and associations most frequently mentioned by respondents when asked how they personally perceived the lionfish on Bonaire.


**Figure 31**. Word cloud: respondents' perceptions of the lionfish on Bonaire

Despite the fact that the lionfish is feared for the potential harm they may inflict on the marine environment, as previously stated, the lionfish density is currently in control (Respondent #2, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #18, 2022; Respondent #19, 2022).

### *Tourist Involvement in Invasive Species Control*

The fact that the lionfish numbers are stable, meaning the density is in control due to human culling efforts, is almost entirely attributed to the resident hunters opposed to the tourists that engage in the specialty course and guided lionfish hunting dives (Respondent #2, 2022; Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). Respondents provided estimates of 20% of total efforts accounting to tourists, opposed to 80% of total efforts referring to resident lionfish hunters (Respondent #3, 2022; Respondent #14, 2022; Respondent #16, 2022). Further, respondent #2 mentioned the top ten divers that belong to these same resident lionfish hunters amounting to 20 to 30 per cent of total lionfish catches (2022). In view of the respondents' opinions and given estimates, in terms of contributing to controlling the lionfish density, tourists catch little compared to the resident lionfish hunters and are thus not seen as actual contributors to accomplishing this conservational objective. However, respondents did provide several other reasons for why tourist engagement is still perceived as beneficial. These beneficiaries of tourist engagement provide the reasoning and motivations for dive operators and instructors to continue to offer the specialty course to tourists.

### *Beneficiaries of Tourist Engagement in the Lionfish Hunter Specialty*

The three main reasons given for why tourist engagement in the specialty is perceived beneficial, can be grouped together and include '**environmental reasons**' (N=13), '**to contribute to controlling the lionfish density**' (N=7), and the statement that '**every single lionfish off the reefs is a success**' (N=8). Despite the fact that tourists contribute little to control the lionfish density when compared to the resident lionfish hunters, respondents do appreciate their efforts, nonetheless. Another reason given for offering the specialty course to tourists is for the '**commercial aspect**' (N=9), which is beneficial for the residents, contributing to the local economy. Aside from the dive operators, offering the course to tourists will also benefit the fishery sector as well as restaurants (Respondent #1, 2022; Respondent #8, 2022). Furthermore, respondents mentioned the motivational factor of '**hunting for personal consumption and selling lionfish meat**' (N=6), stating the price for lionfish fillet to be sold at 50 USD per kilo, superseding tuna prices (Respondent #2, 2022). Moreover, '**educating people and raising awareness**' (N=6) was another beneficial factor widely mentioned. Educating the tourist on invasive species is an important part of this specialty course, and respondents further mentioned that engaging in this course might lead the tourist to engage in other conservation projects as well (Respondent #11, 2022; Respondent #14, 2022). Respondents (N=2) further mentioned that allowing tourists to engage in lionfish hunting allows for a wider area to be covered, for tourists visit locations such as Klein Bonaire, which are sites that are less visited by resident hunters (Respondent #7, 2022; Respondent #8, 2022). On the following page, **Table 10** provides an overview of the dive operators and instructors' intentions and motivations for offering the specialty course.

**Table 10**. Dive Operator and Instructor Motivations for Offering the Specialty Course

| Dive Operator Intentions & Motivations for Offering the Specialty | Respondent (no.) |
|---|---|
| 'To help out the reef' / 'To protect the environment' | 1, 3, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 19 |
| To control the lionfish density | 1, 3, 6, 10, 15, 16, 17 |
| 'Every single lionfish off the reefs is a success' | 1, 2, 3, 10, 12, 14, 15, 16 |
| Commercial aspect | 1, 2, 8, 11, 12, 14, 15, 16, 18 |
| Beneficial for the local community: fishery sector, restaurants, dive operators | 1, 8 |
| Hunting for personal consumption / Selling lionfish meat ($50 per kilo) | 1, 2, 8, 10, 11, 16 |
| Educating people and raising awareness | 9, 11, 15, 17, 18, 19 |
| 'The course acts as a trigger for people to be involved in other conservation projects as well' | 11, 14 |
| By offering the specialty to tourists, a wider area is covered for tourists visit locations that resident hunters do not go as often, such as Klein Bonaire | 7, 8 |
| To help divers expand on their diving competences | 10 |
| To train and educate the STINAPA Junior Rangers | 12 |
| More volunteers to spot and report on lionfish sightings | 18 |

### *Participant Drivers*

Although having slightly similar motives, the tourists that engage in the specialty course have their own reasoning for why they choose to participate, as indicated by respondents. The two drivers that are most frequently mentioned can be grouped together and are '**environmentalism'** (N=8) and '**education'** (N=5). Participants are driven by the feeling of doing something beneficial for the reef. Both of these factors have the ability of raising awareness regarding the invasive lionfish and its implications for the reefs of Bonaire. Respondents furthermore pointed out the fact that this specialty course grants people the privilege of being able to hunt within a restricted MPA, which is an exceptional global opportunity (Respondent #11, 2022; Respondent #13, 2022). For this reason, amongst others, '**novelty, adventure and thrill**' (N=7) was another driver frequently mentioned by respondents. By participating in this specialty, divers experience feelings of excitement, adventure, and are able to add another active component to their holiday itineraries. Moreover, respondents mentioned the course being a '**fun activity**' (N=6), capable of evoking feelings of happiness and enjoyment. Further, '**morbidity'** (N=4) was mentioned. Respondents stated for some participants to be familiar with other types of hunting and engage in the specialty to expand on their hunting and killing skills. Lastly, the driver of '**consumption'** (N=4) was mentioned, where participants experience their efforts being rewarded by having consumed their personally caught lionfish. On the following page in **Figure 32**, a depiction is given of the drivers of participation most frequently mentioned by the respondents, accompanied with **Table 11** that lists those respondents.

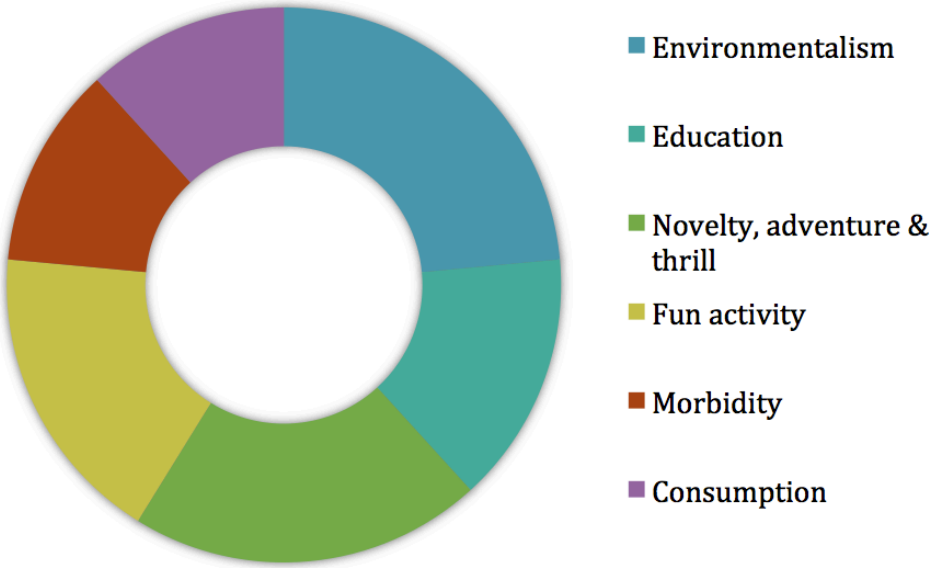


**Figure 32**. Drivers of Participation

**Table 11**. Drivers of Participation

| Drivers of Participation | Respondent (no.) | Total (N) |
|---|---|---|
| Environmentalism | 6, 9, 10, 11, 12, 13, 15, 15 | 8 |
| Educational purposes | 6, 10, 15, 17, 18 | 5 |
| Novelty, adventure and thrill | 8, 11, 12, 13, 16, 17, 18 | 7 |
| Fun activity | 6, 9, 11, 12, 15, 17 | 6 |
| Morbidity | 8, 11, 14, 18 | 4 |
| Consumption | 6, 10, 11, 15 | 4 |

When asked to label this social practice as a tourism activity, for all of the above-mentioned drivers of participation, respondents state for it to be a combination between **adventure tourism** (N=8), **eco-tourism** (N=4), and **sustainable tourism** (N=3). For this reason, respondent #15 mentioned that this specialty could be marketed in three different areas (2022).

### *Possible Risks and Adversities of the Lionfish Hunter Specialty*

Besides factors that are perceived beneficial, such as helping to control the lionfish density and providing a stream of income for residents, the specialty also carries with it certain risks that received a negative connotation.

By far, the factor most widely mentioned amongst respondents (N=14) is two-fold, and results from inadequate use of the ELF as well as hanging on to coral reef, structures, or lying on the seabed. This behaviour results in reef damage by hitting the coral instead of the lionfish, or failing to successfully target the fish by which it adapts its behaviour and becomes wary of divers. Few respondents (N=3) specifically mentioned that tourists form the group that are most responsible for this damage, opposed to the resident hunters (Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022). This reef damage formed the reason for some respondents (N=3) to have deemed the efforts of the tourists as unnecessary and even counterproductive when it comes to controlling the lionfish density (Respondent #3, 2022; Respondent #7, 2022; Respondent #8, 2022).

*In the beginning, "a local […] also […] misses a few fish. But one once he becomes a regular hunter, he will make up for it. […] For the few fish he missed and things that didn't go quite right, he will make more than up for it later as he continues to hunt on the reefs"*
(Respondent #7, 2022)

Another negative aspect mentioned by respondents (N=2) was that certification provides tourists a false sense of security (Respondent #8, 2022; Respondent #15, 2022). After having received their specialty card tourists now carry the title of Lionfish Hunters, while at the same time not being adequately competent or lacking the experience. Further, respondents mentioned (N=2) that instructors might grant certification, simply because the participant paid for the course despite their lack of competence that makes for a proficient Lionfish Hunter (Respondent #7, 2022; Respondent #12, 2022). The questions then arise: what does that say about the level of competence of certified divers, or the consistency between the divers' skill levels? These questions will be further discussed in the upcoming chapter ***Zooming-in Versus Zooming-out***.

Added to the risks of hunting lionfish includes an increased chance of decompression stops, for people neglecting certain rules of diving because their focus lies elsewhere (Respondent #18, 2022; Respondent #19, 2022).

The risk of getting stung by lionfish was mentioned (Respondent #19, 2022), and people that experience a form of PTSD because of a sting, where after they stop hunting all together (Respondent #14, 2022). Hunting lionfish also bears the risk of encountering aggressive moray eels (Respondent #7, 2022; Respondent #11, 2022).

Overexcitement could cause lionfish hunters to harm a fellow diver (Respondent #10, 2022). When a hunter successfully hit a lionfish that is now on the other end of their ELF, waving that tool around may potentially hit another diver.

A final remark on why this specialty could be perceived as rather negative, respondent #10 mentioned, is that the two standardised dives do not provide the time necessary to instil sufficient knowledge or to provide the experience measured in time (2022). As previously mentioned, the course used to be an extension of what it is nowadays and included more dives (Respondent #18, 2022). **Table 12** below provides an overview of the possible risks and adversities of engaging in a Lionfish Hunter Specialty, as mentioned by respondents.

**Table 12**. Factors for why the Lionfish Hunter Specialty course is perceived as harmful to the reef and its participants

| Factors why the Specialty course is perceived as harmful | Respondent (no.) |
|---|---|
| Damage to the coral reef and educating the lionfish, resulting from inadequate use of the ELF and participants holding on to reef structures | 3, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19 |
| Tourists gaining a false sense of security & instructors that certify insufficiently skilled participants | 7, 8, 12, 15 |
| Increased chance of decompression stops | 18, 19 |
| Getting stung by lionfish, resulting in PTSD | 14, 19 |
| The risk of being chased and attacked by aggressive moray eels | 7 |
| Overexcitement resulting in harming another diver | 10 |
| Two dives being insufficient to lead to competent Lionfish Hunters | 10 |

### *Criticisms on Tourist Engagement*

As mentioned in a previous chapter, the majority of people that participate in this specialty are the tourists (Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #17, 2022; Respondent #18, 2022). On one hand, their efforts are recognised as having multiple benefits to the environment, the community and society as a whole, which were described in earlier paragraphs. On the other hand, tourist engagement did generate several consequences, which were perceived as rather negative. For this reason, various respondents (N=7) have expressed their criticisms towards tourist engagement in the specialty course (Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #18, 2022; Respondent #19, 2022).

As stated by STINAPA, one of the objectives of the creation of the Lionfish Hunter Specialty course was to involve more people in invasive species management, with the goal of controlling the lionfish density (Respondent #2, 2022). Several respondents (N=5) did, however, state that the efforts of tourists did not prove effective in bringing down the number of lionfish, and were thus deemed as unnecessary (Respondent #3, 2022; Respondent #7, 2022; Respondent #12, 2022; Respondent #18, 2022; Respondent #19, 2022). It was widely recognised (N=13) that the people responsible for controlling the lionfish density are the active resident lionfish hunters (Respondent #2, 2022; Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). The main reasons for the efforts of the tourists being redundant, is for they lack the time and knowledge to become truly experienced lionfish hunters (Respondent #18, 2022; Respondent #19, 2022).

Especially the risk of damage to the reef by hitting corals and holding on to those structures was mentioned (N=14) to be a major risk. The fact that the majority of that damage is caused by tourists (Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022), makes for respondents to be especially against tourist engagement. Respondents (N=3) mentioned that offering this course to tourists is, more than anything, simply another way of selling the specialty (Respondent #8, 2022). With its primary objective to be for commercial reasons, which favours Bonaire's dive tourism industry (Respondent #7, 2022; Respondent #8, 2022; Respondent #12, 2022). The Lionfish Hunter Specialty courses are perceived as beneficial, however, should only be taught to local residents or specific kinds of tourists (Respondent #6, 2022; Respondent #12, 2022; Respondent #19, 2022).

*''Hunting should be done by specific people, not just any random tourist that you can sell a course to''*
(Respondent #6, 2022)

In spite of respondents having mentioned that most damage by hunting lionfish is inflicted by tourists, Rijna, Lieutenant Governor of Bonaire (*See **Fig. 33***) stated that these are at best anecdotal statements (2022). Rijna further mentioned that offering and engaging in these courses are underlined with good intentions. There are no data available on the matter, and before any further conclusions, an evaluation assessment or other type of analysis should be conducted to analyse whether excessive damage to corals is caused by resident, or tourist lionfish hunters (Respondent #1, 2022).

**Figure 33**. Lieutenant Governor Edison Rijna, Demonstrating the Marine Life Hand Signal of 'The Lionfish'

### 6. 4. A Glimpse Into The Future

When it comes to painting a picture of the future with regards to the problem of the invasive lionfish, respondents imagine it to go either one of the two ways. Where, on one hand, respondents pictured a rather doomsday scenario where the lionfish has completely taken over the reefs, have become the primary predatory species, and decimated everything along its path. That is, on occasion that human control efforts were to have ceased and the lionfish were given enough space and time to establish themselves and dominate the reefs (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19). Cleaning stations have disappeared, the juvenile fish were cleared out, and species like the parrotfish are nowhere to be found.

On the other hand, an ideal situation was pictured. As respondent #2 mentioned, the best-case scenario for Bonaire is for a revival and abundance of large groupers (2022). Others have stated that in time, other medium sized predatory fish such as the green morays and snappers might learn to go after young, uninjured and healthy lionfish on their own, without human intervention (Respondent #1, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #11, 2022; Respondent #15, 2022; Respondent #19, 2022). In case this fails to happen, respondent #1 shared his thoughts about perhaps looking into scientific ways to introduce other predatory species that will (2022). Supposing that there are sufficient natural predators that keep the lionfish population limited and human intervention is no longer necessary, few respondents have stated that it will then be time to halt the control efforts and the ELFs shall be called back by STINAPA (Respondent #6, 2022; Respondent #7, 2022; Respondent #19, 2022).

Whether human control efforts continue, change their methodology, or stop altogether, the true impact of the invasive lionfish will not be determined any time soon. As Respondent #9 mentioned, the problem of the invasive lionfish is a relatively new one and has only been noticed around Bonaire's waters since October 2009 (2022). Hence, only in the long-term will we see the consequences of the establishment of the lionfish into Bonaire's waters as well as the efforts that tried to combat this problem. The only certainty that can be stated, and was widely agreed upon, was that the lionfish will not be eradicated, and has now become part of Bonaire's ecosystem (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #4, 2022; Respondent #5, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #9, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). Although the lionfish has become part of the marine environment, whether they are welcome is another question entirely. A comment concerning invasive species that respondent #18 stated was that the introduction of different species is a continuous one, and that there will always be species circulating around the globe (2022). Whether induced by human intervention or not. Furthermore, even if man chose not to intervene, few respondents said to believe that nature will balance itself out eventually (Respondent #4, 2022; Respondent #5, 2022; Respondent #11, 2022; Respondent #12, 2022).

### *Future Research*

Respondents did suggest certain future studies that could be done on the matter, which might lead to more insight as well as direction regarding invasive species management. With respect to the lionfish, an enquiry that was put forward by respondent #12, was whether and how the lionfish behaviour has adapted towards humans (2022). It was hypothesised about how they might be able to pass on certain information unto their offspring after they were hit but managed to survive. Respondent #14 went even further to mention that when lionfish perceive danger coming from humans, they seem to have found other ways of communication to warn their peers, perhaps by either vocalisation or an unspoken form of communication (2022).

Another opportunity for research could focus on the impact the lionfish has on the reefs of Bonaire. Since its diet consists of mostly small or juvenile native reef fish, it would be interesting to study how abundant native reef fish populations were prior to 2009, as well as on where they stand in current times, measured in both lionfish *fished* areas as well as *unfished* areas (Respondent #2, 2022). As mentioned in an earlier chapter, the research could focus on whether or not native reef fish populations are lower in areas with a higher lionfish density (*See **Fig. 34***). Nonetheless, with this data alone it would still be difficult to determine that, would they be diminishing numbers, could be attributed to the lionfish alone, for the multitude of variables that are present.

A further subject worth looking into, respondents mentioned, is to shift focus to the possible predatory species of the lionfish on Bonaire and see whether the spine punctures and toxins negatively affects them after ingestion (Respondent #3, 2022; Respondent #15, 2022).

Lastly, another field of study could focus on whether tourists are responsible for more damage to the reef than resident lionfish hunters (Respondent #1, 2022). As respondent #1 mentioned, an evaluation assessment or other type of analysis should be conducted to determine the matter (2022).

**Figure 34**. Transact Locations that Measure the Annual Lionfish Density on Bonaire (Respondent #2, personal communication, July 25, 2022)

### *The PADI Distinctive Lionfish Hunter Specialty Course: Innovations*

When the participants were asked about how they would envision innovation with respect to engaging in a scuba Lionfish Hunter Specialty course, one respondent did state that the best way to go forward is to go backward. The specialty entails two hunting dives, but according to respondent #10, people would be taught much better knowledge and skills through four hunting dives (2022). Prior to the specialty becoming available for the wider public, the one-on-one training provided by the BNMP staff included three dives (Respondent #13, 2022).

Respondent #15 would like to see checkout-dives to become standardised, which could serve as an indication of a diver's competence level prior to engaging in a Lionfish Hunter Specialty course (2022). Furthermore, many respondents have expressed for the specialty course to be beyond the qualification level of a mere Open Water Diver (Respondent #10, 2022; Respondent #12, 2022; Respondent #15, 2022; Respondent #18, 2022, Respondent #19, 2022). For this reason, any future adjustments with respect to the course requirements could result in allowing Advanced Open Water Divers and beyond to participate in the specialty course. Moreover, as suggested by respondents, future adjustments or course combinations could focus on integrating other specialty courses such as, Enriched Air Certified Nitrox, Technical Diving Certification, and a Rebreather Diver Course (Respondent #8, 2022; Respondent #12, 2022; Respondent #17).

A last comment was shared with regards to innovations about the Zookeeper. Respondent #13 predicted that in the future, Zookeepers might be designed so to not circulate the water out, which keeps the blood and its scent in, resulting in reduced chances of attracting predatory fauna (2022).

### *Directions for Government and Civil Society*

Respondent #19 suggested the idea of increasing the marine park fee (2022). In this manner, these revenues could be further invested to fund conservation projects while at the same time reducing the amount of scuba divers on the reefs. Respondents have commented on the excessive amount of dive activity on the island, which adds to the pressure on the coral reefs (Respondent #1, 2022; Respondent #2, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #19, 2022).

Furthermore, respondent #15 pointed out that the customs department should try to pay more attention to the fact that people are bringing in their own spears (2022). Although some respondents mentioned the residents being the ones using illegal spears (Respondent #12, 2022; Respondent #14, 2022), most respondents stated that both residents and tourists are guilty of this (Respondent #2, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #18, 2022; Respondent #19, 2022). The tourists that have been spotted mostly made use of a Hawaiian sling or a Lionator pole spear (Respondent #7, 2022; Respondent #15, 2022). The detrimental factor, respondents mentioned, lies in the fact that people use them to spear fish other than the lionfish.

Respondent #2 did mention that law enforcement cannot control underwater activities 24/7, and the open ocean makes for almost no oversight (2022). Nonetheless, respondents did express that STINAPA should be more aware of the harmful practices of divers in general and should take more efforts to control and provide repercussions to those that neglect the marine park rules (Respondent #6, 2022; Respondent #12, 2022).

### *What About Tourism?*

According to respondent #19, not only should the marine park fee increase, but the tourist tax should increase as well (2022).

In an earlier chapter it was already discussed that tourists and scuba divers are the groups most responsible for the harmful practices they inflict on the marine environment (Respondent #1, 2022; Respondent #2, 2022; Respondent #3, 2022; Respondent #6, 2022; Respondent #7, 2022; Respondent #8, 2022; Respondent #10, 2022; Respondent #11, 2022; Respondent #12, 2022; Respondent #13, 2022; Respondent #14, 2022; Respondent #15, 2022; Respondent #16, 2022; Respondent #17, 2022; Respondent #18, 2022; Respondent #19, 2022). Respondent #19 commented on this by stating that if the tourist were more educated prior to their arrival, they would be ''*better received by the local dive community if they came in with more of an awareness and education*'' (2022). Respondent #12 supports the idea of improving awareness and education efforts of the tourists (2022). The respondent mentioned that the shift of the physical tag (*See **Fig. 35***) to the E-tag (*See **Fig. 36***) is partly responsible for this. Where in the past tourists had to pay for their tag directly through dive shops and receive their information in person, nowadays, this is done online. This creates the risk of people skimming over the information, failing to retain it properly. A collaborative effort between the government and STINAPA should conceive of an awareness campaign, targeted at divers (Respondent #12, 2022; Respondent #19, 2022). When I shared that the management of the Galapagos National Marine Park put in place exactly such an awareness campaign, respondents #12 and #19 proposed Bonaire to undertake similar efforts. During the flight from the mainland of Ecuador to the Galapagos Islands, passengers receive a copy with the marine park rules listed, which they each have to read and sign before landing and arriving at the Galapagos National Marine Park.


**Figure 35**. Marine Park Tag

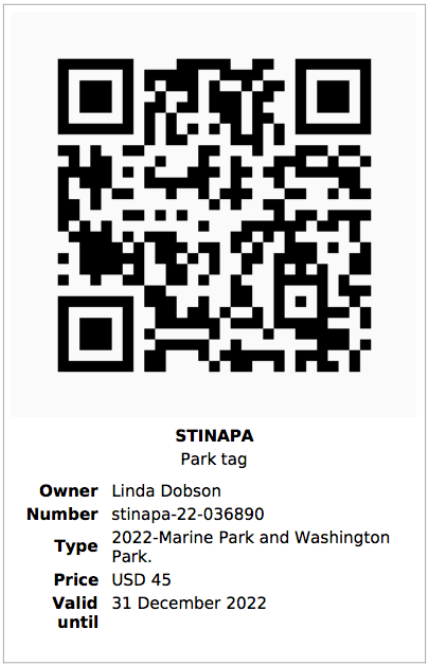


**Figure 36**. Marine Park E-tag

## 6.5. Results Summarised Through a Social Practice Lens

### *Enabling Factors*

The enabling factors combine the three elements of *materials*, *meanings*, and *competences* that allow for a social practice to take place. For the case of engaging in a Lionfish Hunter Specialty course on Bonaire, **Figure 37** depicts the key highlights of these elements. A more extensive description of each of these elements has been discussed in previous paragraphs. Under the **competences** section in **Figure 37**, additional specialty courses are listed that may support and complement a diver's lionfish-hunting abilities.

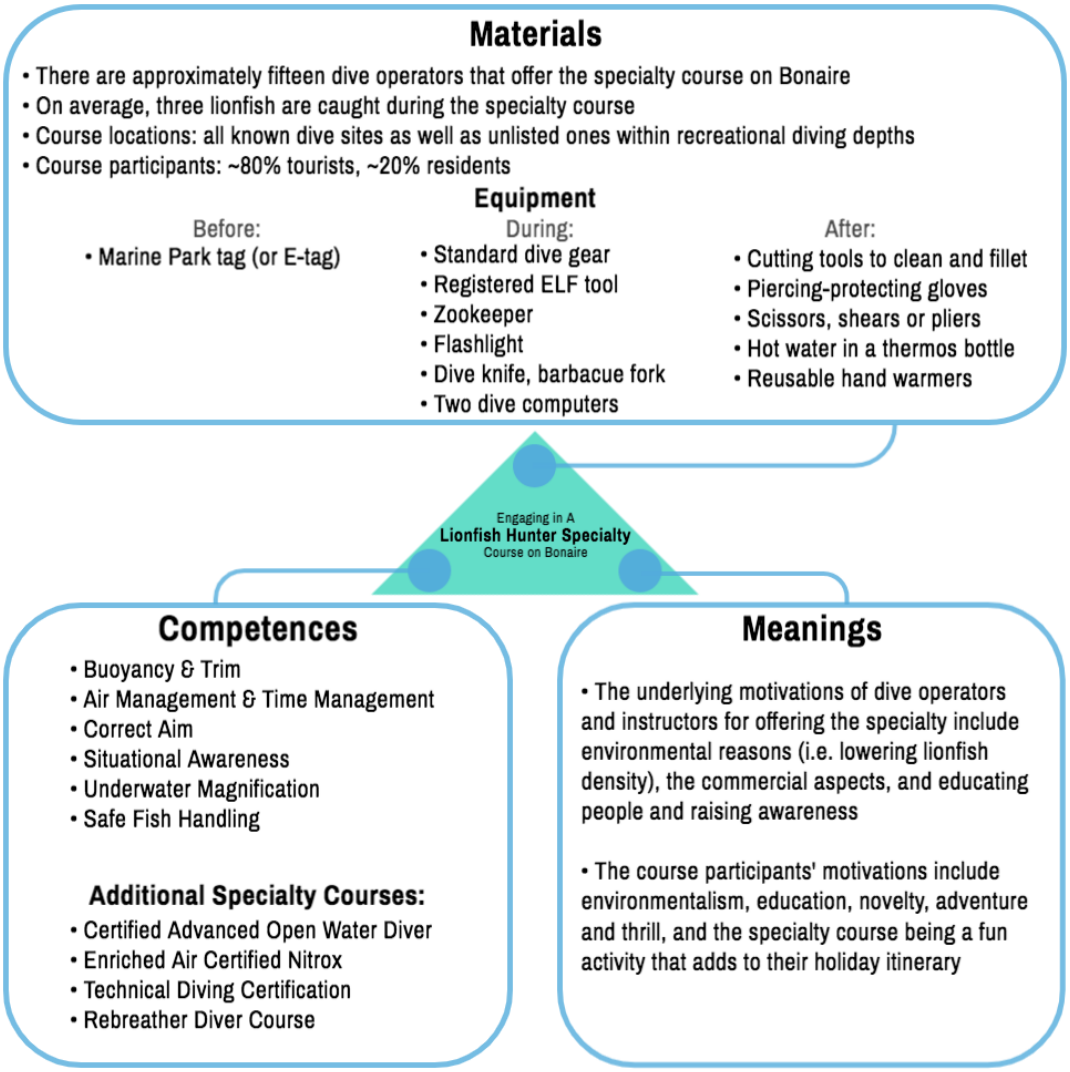


**Figure 37**. Enabling Factors of Engaging in a Lionfish Hunter Specialty Course on Bonaire

### *Bundles of Practice*

The practice of engaging in a Lionfish Hunter Specialty course can be regarded as a bundle of various practices. These **bundles of practice** were derived from the course itinerary discussed in the earlier chapter **PADI Distinctive Specialty Course: Lionfish Hunter in Bonaire**, and include the following:

- Payment and filing paperwork
- Information provision: lecturing, briefing, knowledge review
- Scuba gear set-up
- Transportation to dive site
- Practise use of ELF by shooting a lionfish dummy on dry land
- Hunting Dive 1: practise shooting a lionfish dummy under water
- Information provision: de-brief dive 1
- Hunting Dive 2: attempt to find and shoot actual lionfish
- Information provision: de-brief dive 2
- Upon exiting the water, removal of wetsuit and post-dive equipment care
- Cleaning, filleting and preparing the fish for consumption

As the above list implies, the core practice of engaging in a Lionfish Hunter Specialty course can be interpreted as various bundles of practice underlined by the *competences*, *materials*, and *meanings* that support the practice. The core practice itself is bundled with other social practices that each constitute their own actors, materials, competences and meanings. These supporting social practices can be understood as practice-arrangement bundles. In the case of engaging in a Lionfish Hunter Specialty course on Bonaire, the following list includes a few of the **practice-arrangement bundles** that apply:

- Scuba dive equipment manufacturing and delivery
- Scuba air tank refill services
- The government and STINAPA that are involved in policy and planning – Bonaire Lionfish Management and Control Plan, invasive species management and supporting legislation
- Information delivery: the research and data that become available from locations outside Bonaire that carry out invasive species management concerning lionfish
- Hospitality *complexes*: dining and accommodation services for tourists
- Harbour *complex*: import infrastructures and practices
- Flamingo Airport *complex*: transportation connected to airline companies

All of these interconnected practices form part of **Bonaire's scuba dive tourism chain**. Engaging in a Lionfish Hunter Specialty course becomes co-dependent on these bundles, which in turn creates new demand for these practice-arrangement bundles. The co-dependent linkages that are created result in routinised type of collective behaviour with practices that are continuously reproduced. On the following page in **Figure 38**, a conceptualisation is given that illustrates the wider network that connects the core practice of engaging in a scuba Lionfish Hunter Specialty course to other social practices. The larger turquoise triangle in the middle represents the core practice of engaging in a Lionfish Hunter Specialty course, where the white dots represent the *meanings*, *materials* and *competences*, which are the enabling factors that make up the practice. These same white dots are represented within the smaller blue triangles as well, and are implied, though not illustrated in the even smaller pink triangles. The blue triangles

depict the practice-arrangement bundles, whereas the small pink triangles illustrate the social practices that are interwoven with those bundles.

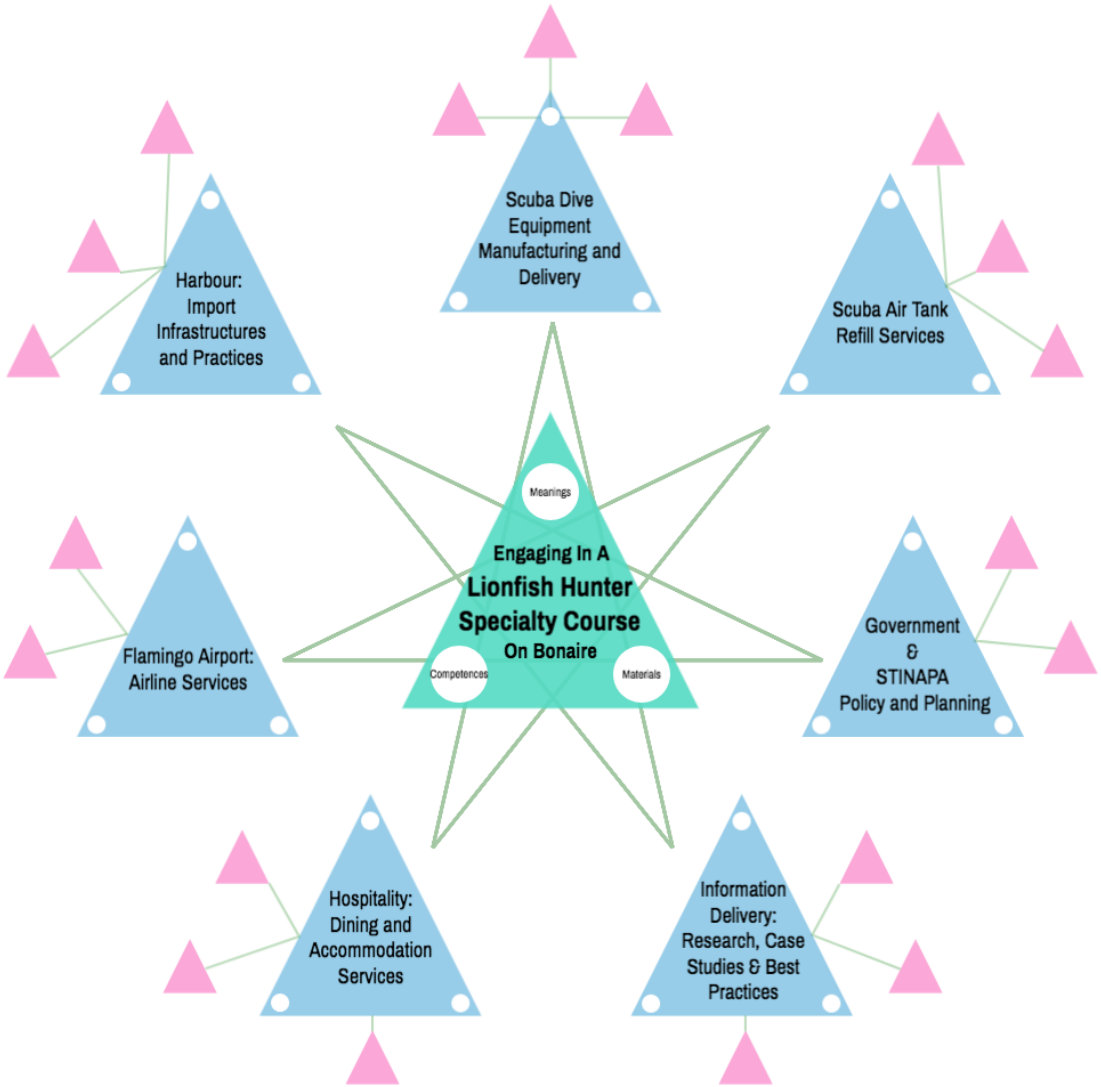


**Figure 38**. Conceptualisation of the network grid that connects the core practice of engaging in a Lionfish Hunter Specialty Course to other social practices

### *Intended and Unintended Consequences*

According to respondents, the **positively perceived intended consequences** of the practice of engaging in a Lionfish Hunter Specialty course were synonymous with the intentions and motivations they mentioned for why they chose to offer this specialty. All of these intended consequences were perceived as beneficial to the local economy, the marine environment, or the people that engage in such a course. These statements were discussed in an earlier paragraph, namely ***Beneficiaries of Tourist Engagement in the Lionfish Hunter Specialty***, along with the corresponding respondent numbers.

One of the **negatively perceived intended consequences** was damage to the coral reef by means of hunting lionfish, and formed the reason for the specific design of the ELF tool as well as why only residents are allowed to hunt on their own whereas tourists only under strict supervision (Respondent #2, 2022; Respondent #3, 2022; Respondent #7, 2022; Respondent #10, 2022; Respondent #14, 2022; Respondent #17, 2022; Respondent #19, 2022). Furthermore, the deliberate design of the ELF minimised the chance of hunting species other than lionfish.

As for the **negatively perceived unintended consequences**, the respondents provided a list of consequences resulting from engagement in the Lionfish Hunter Specialty course. These have been discussed more extensively in the paragraph ***Possible Risks and Adversities of the Lionfish Hunter Specialty***.

There were also **positively perceived unintended consequences** with respect to the Lionfish Hunter Specialty course. Respondent #10 mentioned being surprised to find out that the management efforts were proven effective, and that it was actually possible to reduce the number of lionfish (2022). Another unintended consequence according to respondent #14 was that allowing the wider public to participate in this specialty resulted in a boost of local economies in places outside of Bonaire (2022). Reason for this is because the people that participated in this specialty might have felt inspired to do other types of conservation work in either their home country or elsewhere. Moreover, although not being the main focus of the specialty, respondent #16 stated that the course turned out to be an opportunity for divers to work on their buoyancy control (2022). Respondent #17 mentioned feeling ecstatic when teaching the course, for the feelings of joy the participants share and express while engaging in the specialty (2022). Lastly, respondent #19 shared this feeling of excitement and stated that hunting lionfish is able to revive someone's passion for diving, keeping them actively involved in case they lost interest in the activity (2022).

As explained in **Part I**: **2. Theoretical Framework**, another way of interpreting these consequences is by applying the SWOT-principle. Where the positively perceived intended consequences present the practice's *Strengths*, the negatively perceived intended consequences represent its *Weaknesses*. The positively perceived unintended consequences can be seen as *Opportunities*, whereas the negatively perceived unintended consequences represent *Threats*. On the following page, **Figure 39** provides an overview of the intended and unintended consequences of engaging in a Lionfish Hunter Specialty course, as mentioned by respondents. The statements listed under a green plus sign (**+**) represent those that were perceived as positive and the statements listed under a red minus sign (**−**) were perceived as rather negative.

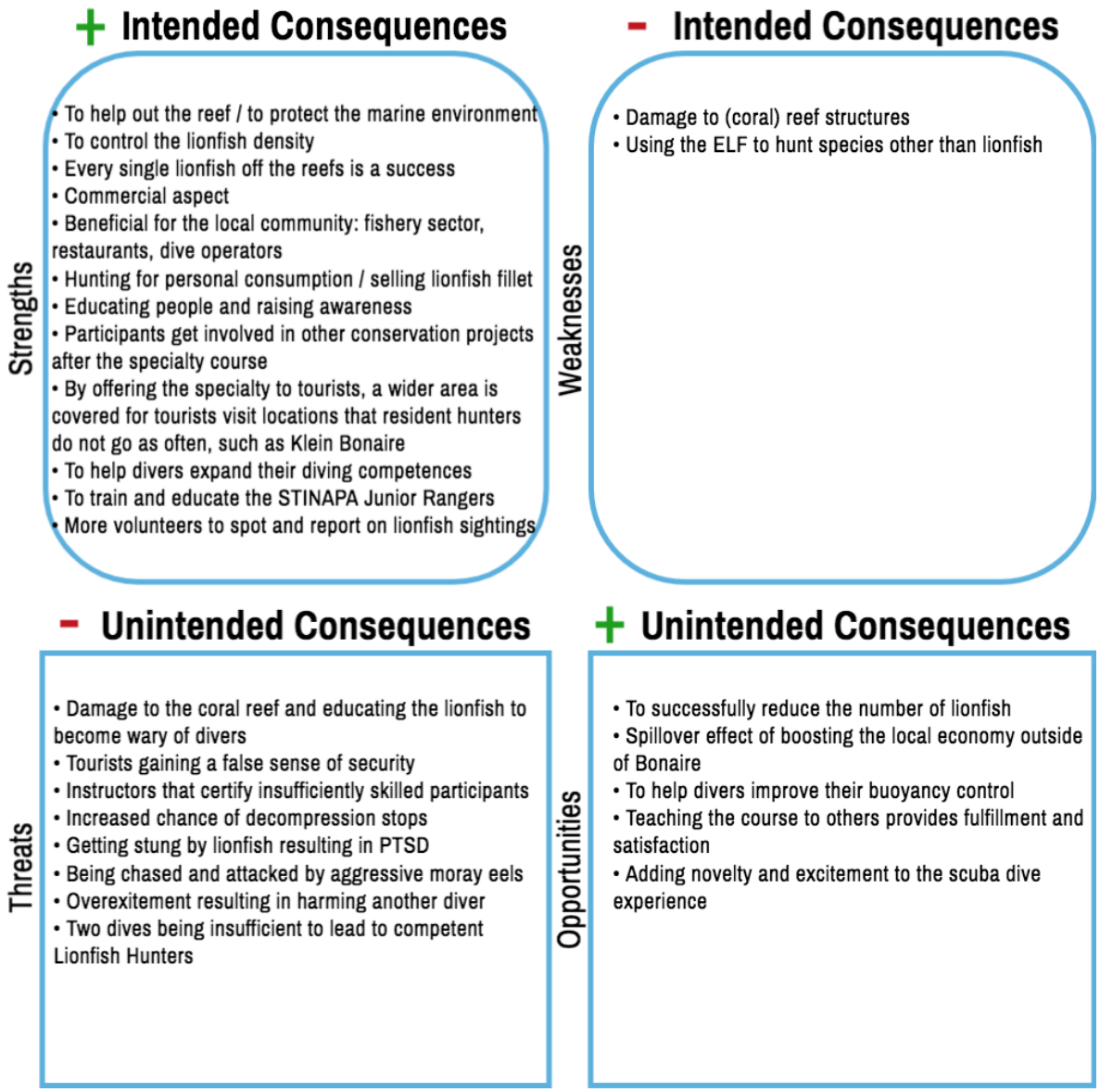


**Figure 39**. SWOT Matrix of the Intended and Unintended Consequences resulting from engagement in a Lionfish Hunter Specialty Course on Bonaire

### *Zooming-in Versus Zooming-out*

Most of the content of this report was dedicated to mapping out the practice of engaging in a scuba Lionfish Hunter Specialty course in great detail, zooming into the different elements of the practice. In order to expand the scope of observation we can zoom out and hypothesise the connections and implications that the practice has on a wider, and even global scale. Naturally, due to the nature of the practice being interconnected with a myriad of other social practices as discussed in the previous subchapter, there are many implications for wider society. Nonetheless, due to the limited time frame I will only shed light on a couple.

A first point of inquiry has to do with a thought experiment when combining elements described in subchapter ***Beneficiaries of Tourist Engagement in the Lionfish Hunter Specialty***, and ***Possible Risks and Adversities of the Lionfish Hunter Specialty***.

One of the benefits, which was also shown to be a positively perceived unintended consequence, was that after engagement in the practice, participants seem to be motivated to engage in other conservation projects outside of Bonaire. When this is combined with the negatively perceived unintended consequence of instructors that certify insufficiently skilled participants, however, may result in harmful practices. These tourists have gained a false sense of security and are now self-proclaimed Lionfish Hunters as a result of certification. Although not permitted, these people might go hunting lionfish in places where legislation and law enforcement is less strict than on Bonaire.

When zooming out, what implications does this have on coral reefs worldwide, since reef damage was reported to be more common amongst novice and tourist lionfish hunters? Moreover, what implications does this behaviour have for their own safety and that of others?

Secondly, as stated in **Part II**: **4.1. A Historical Timeline**, when the spearfishing legislation was passed, the policy makers made sure to maintain a certain level of flexibility as to which spears would be allowed to use. Instead of deciding upon a fixed tool and be bound by that, the marine park manager was empowered to make that decision as to which kind of spearfishing tools the volunteers would be allowed to use. This flexibility implies that in the future, the choice of spear may be altered. In the same chapter, it was shown that STINAPA created the lionfish management and control plan that the staff initiated even before the first lionfish was sighted on Bonaire. As discussed in chapter ***Bonaire: An Exemplary Case in Caribbean Invasive Species Management***, decisions on management and control were based on research and case studies from other coastal and Caribbean destinations that faced the same problem. In this moment, when zooming in on the core practice, which in this case is engaging in a Lionfish Hunter Specialty course on Bonaire, the only permitted tool for both the residents and tourists is the ELF.

When zooming out, however, it becomes evident that the practice-arrangement bundle of information delivery from other case studies and best practices co-defines and could alter the core practice as a whole. Bonaire itself has been cited in academic literature as an exemplary case when it comes to marine park management. Hence, this creates a type of feedback loop where different social practices interact and evolve over space and time. Since the invasive lionfish has become such a widespread problem, now reaching the waters around Brazil and Greece, what implications does the case of Bonaire and their management efforts have on other destinations that also base their management decisions on information delivery? What could these practice-arrangement bundles even mean to other types of marine invasive species management, worldwide?

Lastly, as previously mentioned in the paragraph ***Criticisms on Tourist Engagement***, before the practice was turned into an official PADI Distinctive Specialty, the course used to be an extension of what it represents today, in both theory and practice. Furthermore, during many informal conversations people expressed their general discontent about PADI's business approach.

PADI seems to be the most well-known and preferred choice amongst divers and tourists around the globe, while at the same time growing at the expense of the quality of their courses. Physical classrooms are replaced by online environments and books are replaced by bite-sized videos. As for the course content, when following an online course, PADI included advertisements for their own courses that appear to be so important as to include them in their knowledge reviews. After completion, the online information will only be available to the student for a limited amount of time. In ***Part III: Discussion***, I will attempt to dive deeper into this topic by comparing these informal statements to the available scientific literature.

And so, when zooming in it seems that there is some criticism on the PADI Distinctive Lionfish Hunter Specialty, which forms part of Bonaire's wider scuba dive industry. When zooming out, however, this criticism can be attributed to PADI's protocols and practices described in the aforementioned paragraph. Resulting from these dealings, the following question remains: how do these changes affect global skill levels and diver mentalities? The outcome of this set of practices will circle back to Bonaire, for the island is known for being a touristic scuba dive paradise. The level of competency and the mentalities of those tourists will in turn affect and co-define the core practice that is engaging in a Lionfish Hunter Specialty course.

In conclusion, although the core practice can be analysed and mapped out by dissecting it in three parts including *competences*, *materials* and *meanings*, they cannot be disconnected from the practice-arrangement bundles that eventually compose them. On the following page, **Figure 40** provides an illustration, which shows that the core practice is, in fact, connected to the wider scuba dive tourism chain, which itself is part of a larger global network.

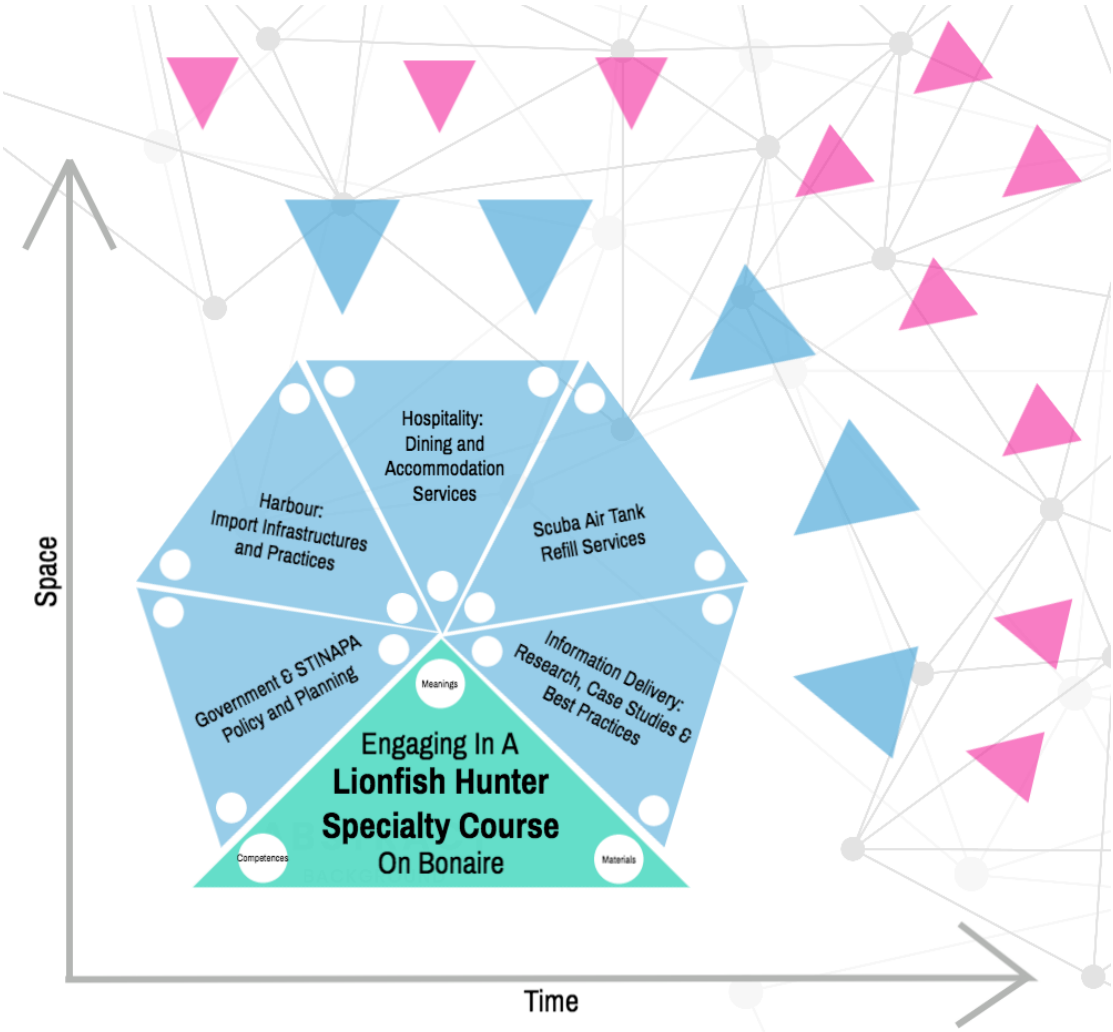


**Figure 40**. Conceptualisation of the core practice being embedded by other social practices that influence each other, co-defining and co-evolving through space and time

## Part III: Discussion

This section presents a summary of the most important results from the **Research Findings** chapter and compares them with the academic literature available on the subject. Various topics will be discussed and implications for future research will be provided. Moreover, I will touch on a few limitations of this study where after I briefly discuss my positionality within this research.

Using a practice-based approach, this thesis demonstrated how engaging in a Lionfish Hunter Specialty course is carried out, and how it evolves over space and time. Using qualitative research techniques, including desk research, field observations and nineteen semi-structured in-depth interviews I attempted to map out the social practice and by zooming in, provided further detailed descriptions on the enabling factors that support the practice. Via the zooming out technique, I was led to further describe the practice-arrangement bundles, which displayed how the practice is embedded in a global network of interconnected practices.

The focus of this research was mainly directed towards the involvement of the scuba dive tourism industry as part of the BNMP's management and control plan concerning the invasive lionfish. The study shows significance because, as demonstrated by zooming out, other coastal destinations around the world such as Brazil or Greece now face the similar threat that the invasive lionfish poses onto their reefs (Ferreira et al., 2015). These destinations depend on scholarly information delivery to base their management efforts on (Hüseyinoğlu & Öztürk, 2018; Ulman et al., 2022), with Bonaire being regarded as an exemplary case (Laffoley et al., 2019; Cox & Alleyne, 2020; Steneck et al., 2019; Thur, 2010; Mandavilli et al., 2022). As the introduction of the lionfish into the Atlantic Ocean and beyond is a relatively new problem, so are the management strategies aimed to combat this problem. It is therefore important to undertake evaluation assessments and other types of analyses as time goes on and this dynamic changes. As Tidbury et al. (2021) state, continuous research efforts are necessary to bridge information on how to enhance strategies for the conservation of marine biodiversity and the maintenance of environmental and economic stability. In this thesis, one of those management efforts was analysed that is the engagement in scuba Lionfish Hunter Specialty courses aimed to control the lionfish density. This study adds to the existing literature regarding marine invasive species management involving the dive tourism industry.

*How do SCUBA Lionfish Hunter Specialty courses contribute to lionfish control efforts and what are the implications of such business-led practices for meeting the conservation objectives set by the Bonaire National Marine Park?*

The introduction of the PADI Distinctive: Lionfish Hunter Specialty course has generated more volunteers to become part of STINAPA's lionfish management and control strategy. As residents need to follow this specialty course only once, the majority of participants consist of tourists. Resident lionfish hunters were reported to be responsible for an estimated 80% of total lionfish catches, whereas approximately 20% of total efforts accounted to tourists. The lionfish density has been statistically stable since the start of observation in 2011. The result of this favourable outcome has been attributed to the active lionfish culling efforts. It was stated that within the limits of recreational diving depths, lionfish body sizes are smaller and in general less abundant

opposed to deeper waters. Moreover, the lionfish that got shot at but managed to survive became wary of divers and adjusted their behaviour accordingly. Due to the changes in lionfish behaviour and abundance, some resident lionfish hunters chose to pursue additional scuba dive courses that include Certified Advanced Open Water, Enriched Air Certified Nitrox, Technical Diving Certification and a Rebreather Course. These additional specialty courses allow for the diver to move through the water more quietly, go deeper, and stay out for longer.

And so, as people experience perceived changes of for instance, a relatively low lionfish density compared to deeper waters, the practice itself changes. In the same manner, as the practice changes so do the meanings, competences and materials required to perform the practice. However, although these enabling factors influence each other and evolve over time, there are limits to these changes. After a certain depth human divers experience physical limits as well as technological limits to the practice.

All things considered, the core practice of engaging in a Lionfish Hunter Specialty course has proven to be of fundamental importance to the conservation objectives of the BNMP with respect to the invasive lionfish, and continues to introduce tourists to serve as volunteers.

Besides conservational objectives, the BNMP also established social and economic objectives. As previously mentioned, the creation of the PADI Distinctive Lionfish Hunter Specialty course allowed tourists to assist with the BNMP's overarching goal of overfishing the lionfish to create a low density. That is, under the condition of strictly supervised hunting sessions that involve a local dive guide. Furthermore, unlike resident hunters, tourists are not allowed to file a permit for the ELF tool that is used to hunt the lionfish on Bonaire. The ELF's deliberate design allowed for more control as to which species of fish people will be hunting, as well as making it more difficult to damage the coral reef opposed to other type of spears. The BNMP's management decision to involve the dive tourism industry would generate more income for local divers. Moreover, a consumption campaign created a greater demand of lionfish fillet for local restaurants, which can now be sold at a price of 50 USD per kilo.

### *Lionfish Density: A Population Crash?*

According to STINAPA's data, the lionfish density has been statistically stable since the start of observation in 2011, albeit with annual fluctuations. Contradictory statements of respondents, however, reported a perceived influx followed by a tapering down of lionfish abundance within recreational depths. A case study by Debrot et al. (2022) observed a similar lionfish population crash, which led them to conclude that in the future human control efforts will be unnecessary. Another case study by Hackerott et al. (2017) found no evidence that the lionfish measurably affected the density, richness or composition of predatory fishes. The outcome of their research could substantiate a halt to human control efforts, would Bonaire decide to do so. However, Hackerott et al. (2017) also concluded that the effect of the lionfish on native reef fish communities at the larger scale remains unknown. A similar conclusion by De Léon et al. (2013) that focused on lionfish removal efforts on Bonaire, stated that it remains unknown whether the reduction of lionfish results in any ecological benefit. It is therefore recommended for Bonaire to collect quantitative data on native reef fish populations at different locations that include the official dive sites as well as the marine reserves. The research could focus specifically on whether or not native reef fish populations are lower in areas with a higher lionfish density.

### *Continuous Lionfish Removal Efforts*

The majority of respondents did express that in this moment, lionfish removal efforts continue to be necessary and will not stop anytime soon. Although Bonaire's marine environment is considered to be in fairly good shape, the decision of active lionfish culling was based on the Precautionary Principle. In a case study by Rojas-Vélez et al. (2019) it was concluded that their data did not support the biological resistance hypothesis of native predators being the phenomenon that controls the lionfish density, implying natural predation might not be substantial. This conclusion was supported by Cobián-Rojas et al. (2018), who evaluated two Caribbean MPAs that each employed different control strategies and consisted of different levels of native fish abundances. Since the twelve Caribbean small reef predators resemble the same ecology of that of Bonaire, the data by Rojas-Vélez et al. (2019) does substantiate the BNMP's decision of continuous control efforts.

### *An Evaluation of PADI Specialty Courses*

Prior to the creation of the PADI Distinctive Lionfish Hunter Specialty course, hunting lionfish only served as a means of controlling an invasive species. The knowledge and competences necessary for this practice were taught via one-on-one interactions between BNMP staff and volunteers and included several hunting dives. In other words, this interaction used to be an extension of what the course represents today, both in theory and practice. Over the course of my fieldwork, during many informal conversations people expressed their general discontent concerning PADI's business approach. Lindgren et al. (2007), Hammerton (2016), and Johansen (2012) provide similar critiques about PADI's protocols and practices. In the case of Bonaire, few respondents criticised the PADI Lionfish Hunter Specialty for only serving as a commercial way of selling the specialty. Lindgren et al. (2007) confirms this by stating that shorter course periods might lead to an increased turnover, even though the preferred method of teaching would be to stretch courses over a longer period of time. Lindgren et al. (2007) further mentioned that courses at holiday destinations are compressed to the absolute minimum, which might help to attract as many tourists as possible. Confirmed by Johansen (2012) and Naidoo et al. (2018), there are limited to no research papers that provide evaluation assessments on PADI courses and protocols. Thus, directions for future research emphasizes on data collection on evaluation assessment reports of specialty courses offered by PADI compared to other dive organisations such as SSI, NAUI, BSAC, SDI and others.

### *Limitations*

Firstly, a commonly known bias when conducting qualitative interviews is respondents providing answers that are socially acceptable, for any given reason. This specific factor could have played a role when respondents were asked to list the intended and unintended consequences of the practice. Any consequences perceived as extremely negative might have been omitted for fear of incriminating themselves or the practice.

Further, even though AB-Dive invited me to attend Part I of the PADI Lionfish Hunter Specialty course, which is the theoretical part, I failed to attend due to time constraints. This session could have proven especially beneficial to answering the second research question that focuses on analysing the course itinerary. I therefore had to rely on the verbal accounts of that specific part of the itinerary. For future replication of this study I recommend to expand the scope of the study by including participant observation on the larger scale via engagement in scuba Lionfish Hunter Specialty courses at all the different dive operators and instructors that offer the specialty on

Bonaire. In this manner, a well-grounded understanding may be fostered, which when combined with the collection of quantitative ecological data may lead to an even deeper understanding of business-led control efforts such as Lionfish Hunter Specialty courses and the consequences and implications the practice holds for the conservation objectives of the BNMP.

Lastly, the objective of this study was to gain a deeper understanding of the involvement of the scuba dive tourism industry as part of a management strategy aimed to control the invasive lionfish, in the unique case of Bonaire. Therefore, since the outcome of this research is restricted to this specific context in space and time, it cannot be generalised and used to understand the entire population (Pham, 2018). In order to introduce the case of Bonaire to the wider scientific debate on the subject, directions for future research could expand the study to the macro scale level, and focus on comparative analyses and data collection of scuba Lionfish Hunter Specialty courses aimed to control invasive lionfish between the different countries that offer them or that employ similar control efforts.

### *Positionality*

Marine ecology has always been a personal interest of mine. However, although the focus of my thesis lay on the practice of scuba diving, prior to coming to Bonaire I only participated in a single scuba dive. Furthermore, as a social scientist studying tourism, I lacked the basic knowledge of that of a marine biologist. With all of this in mind, I conducted this research using a social constructivist approach to grounded theory (Mills et al., 2006).

# Part IV: Conclusion

In the final chapter of this report, I will answer each research question consecutively, and close with a concluding paragraph.

*What are the current objectives of STINAPA when it comes to invasive lionfish?*

Any management decision that involves invasive species will be regarded by applying the Precautionary Principle, where an attempt will be made to either eradicate, or control its numbers. The primary objective for the BNMP regarding the invasive lionfish is the overfishing of lionfish to create a low density and thereby controlling its numbers. The exact number of lionfish that is to be considered a low density was set by the National Plan determined for the wider Dutch Caribbean that established a lionfish density with numbers lower than 50 lionfish per hectare. The second objective was to involve the dive centres by creating an incentive for the dive tourism industry. In this manner, more volunteers were generated to accomplish the first objective, which at the same time generated profit for local divers. Moreover, a consumption campaign was launched that created a greater demand for lionfish fillet, profiting the lionfish hunters and local restaurants.

*How does the practice of engaging in a SCUBA Lionfish Hunter Specialty course look like?*

After payment, participants are required to fill out standardised PADI paperwork. Subsequently, *Part I: Theory* will focus on information provision. Participants are given lectures and briefings, followed by a general knowledge review. Afterwards, *Part II: The Dives* will provide the participants with more in-depth knowledge and demonstrations regarding the use of the ELF, the Zookeeper, and how not to get stung. Participants are told to watch for moray eels and might get assigned different roles (hunter vs. spotter). The next step is practising shooting on dry land with a lionfish dummy. Once successful, it is time for the scuba gear set-up and transportation to the dive site. The focus of *Hunting Dive 1* is to practise aim underwater shooting a weighted lionfish dummy. The participant receives feedback during *De-brief Dive 1*. After that, *Hunting Dive 2* will aim to find actual lionfish. *De-brief Dive 2* includes another feedback session, where after certification is granted. Depending on the dive operator, a third part to the course will include a demonstration of cleaning, filleting, and preparing the fish for consumption.

*What are the enabling factors (i.e. competences, materials and meanings) that allow for engagement in a SCUBA Lionfish Hunter Specialty course to take place?*

First are the *competences*, which includes certain skills participants are expected to hone in on that make for a truly competent lionfish hunter. Buoyancy and trim are the basic principles, followed by air management and time management. Correct aim of the spear is complemented by the principle of underwater magnification. Furthermore, a participant needs to have a certain level of situational awareness and should be able to handle a fish safely.

The second component that allows for the Lionfish Hunter Specialty to take place includes the *materials*. The principal element being the invasive lionfish and its predators, or rather, lack thereof. The locations the practice takes place at include all known dive sites as well as unlisted ones, within recreational diving depths. The dive

operators and instructors are part of the enabling factors, as well as their participants, which include an estimated 80% of tourists and 20% residents. Finally, the equipment necessary to undertake this practice. Participants are expected to have obtained a Marine Park tag, either the physical version or an E-tag. Apart from standard dive gear, a Lionfish Hunter needs to carry an ELF and Zookeeper, should they decide to bring back the lionfish. Recommended items to carry include a flashlight, a dive knife and two dive computers. Moreover, once back on shore useful items can include cutting tools to clean and fillet the fish, and scissors or sharp shears to remove the spines. Lastly, first-aid items to bring in case of a lionfish sting include hot water in a thermos bottle, or reusable hand warmers.

The third enabling factor that provides the foundation that the practice is built on consists of the *meanings*. In particular, the personal perceptions of the lionfish and the role of human involvement in invasive species control. Some of the underlying motivations of dive operators and instructors for offering the specialty include environmental reasons, the commercial aspects, and educating people and raising awareness. The participants' motivations for engagement in the specialty vary, but are somewhat similar and include environmentalism, education, novelty, adventure and thrill, and the course being a fun activity.

### *What are the intended and unintended consequences resulting from the interactions of engaging in a SCUBA Lionfish Hunter Specialty course?*

The *positively perceived intended consequences* were stated to be beneficial to the local economy, the marine environment, or the people that engage in such a course. These included the motivations and intentions of the dive operators and instructors for why they chose to offer this specialty. The main benefit of engagement in the specialty course was stated as environmental reasons with, in particular, the aim of controlling the lionfish density. Another intended consequence was to gain commercial benefits and educating people and raising awareness.

The *negatively perceived unintended consequences* that resulted from engagement in the practice were perceived as harmful to the reef or to its participants. The unintended consequence most frequently mentioned was damage to the coral reef and educating the lionfish to become wary of divers. Respondents furthermore mentioned the risk of tourists gaining a false sense of security and instructors that certify insufficiently skilled participants. Other unintended consequences included an increased chance of decompression stops, getting stung by lionfish resulting in PTSD and being chased and attacked by moray eels. Other factors include overexcitement resulting in harming another diver, and the two standardised course dives being insufficient to lead to truly competent Lionfish Hunters.

Although anticipated, engagement in the specialty course did lead to several *negatively perceived intended consequences*. These include damage to coral reef structures as well as using the ELF tool to hunt species other than lionfish.

Finally, there were *positively perceived unintended consequences*. Included here was the pleasant surprise of successfully reducing the number of lionfish. Further, engagement in the practice caused for a spillover effect of boosting local economies outside of Bonaire. Moreover, the specialty assisted in divers expanding on their buoyancy control and added novelty and excitement to those that had become disinterested in the sport. Lastly, a respondent mentioned how teaching the course provided fulfilment and satisfaction to both the participants as well as the instructors.

## *Concluding Remarks*

In conclusion, the focus of this research was directed towards the involvement of the scuba dive tourism industry as part of the BNMP's management and control plan concerning the invasive lionfish. More specifically, to gain a deeper understanding of business-led control efforts such as Lionfish Hunter Specialty courses on Bonaire and to take a closer look at the consequences of the practice and the implications this holds for the conservation objectives of the BNMP. Ultimately, by offering Lionfish Hunter Specialty courses, more volunteers are introduced and more revenue is generated that benefits the objectives set by the BNMP concerning the invasive lionfish. At the same time, the course allows participants to expand their knowledge and awareness regarding the invasive lionfish. The downside most frequently mentioned by respondents is two-fold, and firstly includes the inadequate use of the ELF and inexperienced divers hanging on to coral reef, structures, or lying on the seabed, resulting in reef damage. Second, failing to successfully target the lionfish by which it adapts its behaviour and becomes wary of divers.

This thesis serves as a case study that adds to the literature on MPA management and, in particular, marine invasive species management involving the scuba dive tourism industry. Keeping in mind that the results of this thesis are constricted to the specific context of Bonaire in space and time, thus any practical implications point towards a continuation of research on the matter. To expand on this topic, future research could perform comparative analyses on dive behaviour and its implications, between the tourists that follow the specialty and resident lionfish hunters to be able to ascertain which type of participants cause for a majority of damage to the reef. Moreover, directions for future research could focus on quantitative data collection of the ecological impact of invasive lionfish on the reefs of Bonaire. Specifically, to assess whether native reef fish populations are lower in areas with a higher lionfish density. Lastly, to gain a more comprehensive understanding of business-led control efforts such as the Lionfish Hunter Specialty course on Bonaire, specialty courses and other similar control efforts could be analysed and compared between the different countries that offer them.

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# Appendices

## Appendix 1: Table with Participant Observation Field Notes

| Date, *time* | Location | Organisation / Dive Operator | Dive Guide | Participants | Duration (min) | Max. Depth (feet) | Notes |
|---|---|---|---|---|---|---|---|
| 24 July 2022 *Late afternoon* | Playa Bengé, Bonaire | STINAPA | Paulo Bertuol | - | ~ 50 | ~ 60 | Objective: scuba lionfish hunting dive. Attempt to find lionfish. Tools brought: ELF and Hawaiian sling. Lots of marine wildlife spotted, none of them being lionfish. |
| 27 July 2022 *Dawn* | 4WheelDiving house reef, Bonaire | 4WheelDiving | Yago Fernández Gutiérrez | Two American tourists that obtained certification one week prior | ~ 50 | ~ 46 | Objective: scuba lionfish hunting dive. My role was to assist in spotting lionfish, observe tourist behaviour and watch for moray eels. Over 30 lionfish spotted, ~15 were caught. The female tourist missed all of her targets, many times hitting coral/stone structures. Small lionfish were killed but left in the water. |
| 29 July 2022 *Afternoon* | The Lake, Bonaire | 4WheelDiving | Yago Fernández Gutiérrez | Four American tourists, of which one couple was that of 27/7/2023 | ~ 50 | - | Objective: scuba lionfish hunting dive. I did not participate but observed as I snorkelled and was present during de-brief. Of the two couples, one couple successfully caught ~7, the other couple caught less. The same female of the previous hunt missed all of her targets once again. |

## Appendix 2: Semi-structured Interview Guide, *dive operator version*

Qualitative Research Instrument: in-depth semi-structured interview guide for dive operators that offer Lionfish Hunter Specialty courses in Bonaire's dive tourism industry

*Inform the participant about the research topic, ask for consent (sign form), and explain that their interview can be completely anonymous so that they have the freedom to speak freely regarding any topic. Start voice recording, state my own name and date, proceed:*

So, the leading question of my research is the following: *How can the social practice of Bonaire's SCUBA Lionfish Hunter Specialty courses be characterised, and what are its implications on conservation goals within the Bonaire National Marine Park?* The reason for why I'd like to answer this question is because Bonaire is known for its excellent management efforts regarding the marine park, and by answering this question I think it can produce valuable information for any other coastal or island community that has to face similar problems regarding invasive marine species.

This interview will be divided up in parts. First, I will ask introductory questions. Then part two will include questions that I hope will answer my research questions. So, for the introduction:

1. Could you maybe introduce yourself, state your occupation, and explain how you ended up here?
2. Do you spear lionfish yourself?
3. When did you first start teaching the Lionfish Hunter specialty course?
4. How popular is the specialty course when you compare it to other specialty courses?
5. Why did you choose to offer these Lionfish Hunter courses?
6. How do you feel about the lionfish, how do you view them? (e.g. threat, an invasive species, or part of the environment)

Now, for the next section of this interview, I will ask questions about three themes that I think are important and will help answer my research questions. The themes are; materials, competences, and meanings. I will ask questions on these themes so we can map out the social practice of engaging in scuba Lionfish Hunter Specialty courses. So the first theme is called **Materials**.

7. Who engages in the scuba Lionfish Hunter specialty courses? What type of people? Is it mainly tourists?
8. Are these courses a singular occurrence, do tourists that have obtained the certificate go out after to hunt lionfish frequently during their stay, do tourists return to the island for the reason of hunting more lionfish?
9. Here on Bonaire, what does the lionfish consume?
10. What predators consume the lionfish (e.g. moray eels)?

    *Probing questions:*
    - I heard they go after already dead or wounded lionfish?
    - Did people try to feed lionfish to the moray eels?

11. Ever since humans stated hunting them, have you observed any changes in lionfish abundance, size, and distribution (perhaps in deeper waters now)?
12. Over the years, have the lionfish adapted their behaviour towards humans and the ELFs?

13. Here in Bonaire, have you noticed any differences between reefs where there isn't any active lionfish hunting, and locations where there is?
14. Is it possible for tourists to spear the lionfish without the assistance/company of a professional dive instructor? If not, are people doing it anyways?
15. What places/routes/locations do you go to hunt lionfish during these courses?
16. On average, how many lionfish would you catch while teaching the course?
17. Can you tell me about the main equipment necessary that's needed for tourists to engage in a Lionfish Hunter course?
18. ELFs: are the ELFs being used at all times, or are other spearguns also used?
19. ELFs: in your experience, do you think the tourists shoot well?
20. When people 'mess up' (poor buoyancy control, missing targets), do they still receive certification?

The following questions will be about the second theme: **Competences**. Which in this case refers to skills, techniques, understanding, knowledge and rules.

21. What are the requirements for people that want to follow a course?
22. What are the competences necessary for tourists to engage in a Lionfish Hunter course?
23. Are these skills taught during the briefing/course or should they possess certain skills already before that?

The next section will be about the third theme: **Meanings**.

24. What is your main goal for encouraging people to participate in hunting lionfish?

    *Probing questions:*
    - For money/profit?
    - To help out the marine environment?
    - To entertain tourists?
    - To gain word-of-mouth advertising?
    - To gain competitive advantage?
    - To share your knowledge to the people?

25. Do you have any aspirations for the future of these courses, any changes you wish to see, or how you would like these courses to evolve?

    *Probing questions:*
    - Expand scuba course offers?
    - To use/employ other types of hunting and catching device other than the ELFs?

26. Do the tourists share with you the reason for why they chose to participate in a Lionfish Hunter course?

    *Probing questions:*
    - To expand their diving skills?
    - To expand their CV/resume?
    - To help out the environment?
    - Because they want to consume their personally caught lionfish?
    - Pure entertainment?

27. What are the people's responses (the thoughts, feelings, attitudes that they share with you) towards the event of hunting lionfish?

28. When the lionfish was first introduced they were labelled an invasive species. Now the research stated they will never be completely eradicated due to the depths they reach, which is beyond recreational diving depths. Is it fair to say that they have now become part of the natural environment that nature is able to balance out, or are they still being considered an invasive species, seen as a threat, and should thus be controlled?
29. How do you envision the future of Bonaire's reefs when it comes to the invasive lionfish?

    *Probing questions:*
    - Will human efforts continue to be necessary?
    - Will the ecosystem balance itself out?
    - Will legislations become stricter or more flexible?

The next couple of questions belong to the final part of this interview. The topic of these questions includes **Intended and Unintended Consequences**. Or in other words, expected, and unexpected outcomes of the social practice of hunting lionfish.

30. How do tourists experience the activity, do they share how they feel afterwards?
31. What are the outcomes that you intend to achieve by offering the Lionfish Hunter courses?

    *Probing questions:*
    - To gain money/profit?
    - To help out the environment?
    - To make people exited to come back and participate?
    - To gain word-of-mouth advertising?
    - To gain competitive advantage?
    - To reduce lionfish populations?

32. What do you personally know about the conservation goals/objectives of the Bonaire National Marine Park, when it comes to invasive species and, in particular, the invasive lionfish?
33. Do you think the introduction of the scuba Lionfish Hunter course is contributing to achieving these conservation goals? If so, in what way?

    *Probing questions:*
    - Is data being recorded and shared with scientists?
    - Are the lionfish being weighed?
    - Do you keep track of the number of lionfish sighted/caught?
    - Are the fish donated for research?
    - Are the lionfish caught to be eaten?
    - Are some of them killed but left in the water?
    - Are the lionfish being kept alive so to not completely eradicate them (to keep the possibility of offering these specialty courses alive)?

34. Who is in charge of assessing whether management outcomes were successful?
35. To what extent are the efforts of tourists (and their engagement in these courses) necessary when it comes to controlling the invasive species?
36. How much does it cost, to engage in a scuba Lionfish Hunter course?
37. How much of the money that the tourists pay for, goes to the private (dive) companies (excluding costs for air tank refills etc.)?
38. Regarding the costs for participating in a Lionfish Hunter course, is any part of it being allocated to fund conservation projects?

39. Do you think that there have been unexpected consequences with offering scuba Lionfish Hunter courses (*these can be either positive or negative*)?

    *Probing questions:*
    - An increase in tourism?
    - Making new contacts/friends?
    - An increase in operational costs?
    - Damage to the reef by poor aim of tourists?

40. What do you do with tourists who cannot shoot well and damage corals? Have there been incidents?
41. How (well) are the Lionfish Hunter courses being marketed/promoted, and who is in charge of promoting these courses?
42. Who takes part in the derbies, do tourists participate in them as well? Are there people that travel for the main reason of hunting lionfish?
43. How would you characterise the tourism activity of scuba Lionfish Hunting (*e.g. sustainable tourism, dive tourism, eco-tourism, volunteer tourism, adventure tourism*)?
44. What is the added value of offering tourists the specialty course?
45. What is the current state of the reef? Is the marine environment considered healthy?

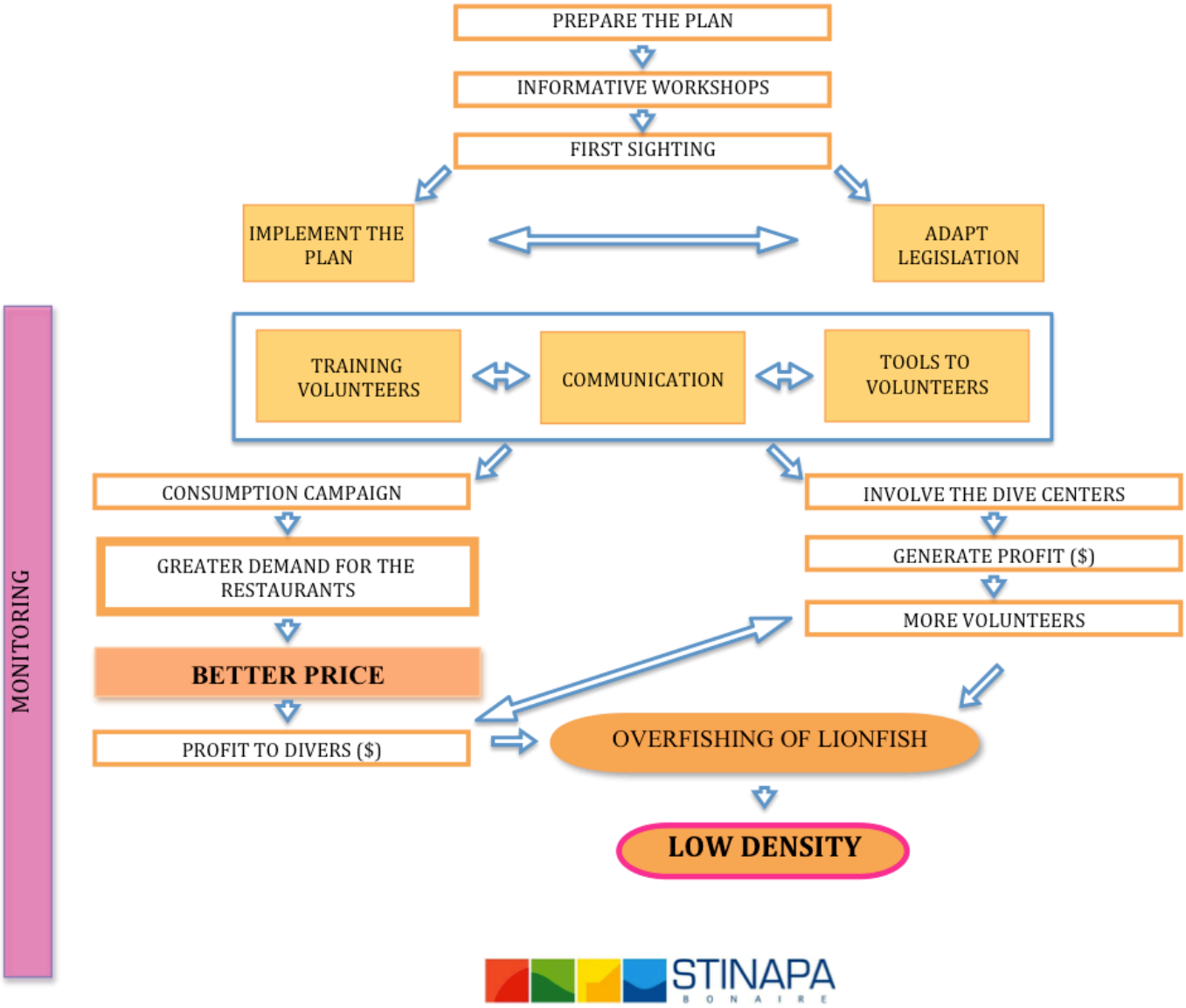
    *Probing question:*
    - If yes, then why is it necessary for humans to intervene and try to control the lionfish density?
    - If the reef is now considered healthy, and the lionfish have been here since 2009, doesn't that mean nature is able to balance out the ecosystem?

46. Are there any changes on the reef and native fish populations today, compared to 2009 when the lionfish was first sighted?
47. What do you think impacts the state/health of the reefs, compared to 30 years ago? And what role does the lionfish play?

    *Probing questions:*
    - Population boom, development?
    - Tourism?
    - Etc.

Thank you so much for taking part in this interview! Let me know if you'd like for your interview to remain anonymous, and if you have any questions for me, you can always reach out. And if you'd like to receive my thesis when it's finished, I'll be happy to share it with you!

## Appendix 3: Bonaire Lionfish Management and Control Plan




(Respondent #2, personal communication, July 25, 2022)

## Appendix 4: ELF Permit Application Form STINAPA

STINAPA BONAIRE
NATIONAL PARKS FOUNDATION

LIONFISH HUNTER INFO

| | |
|---|---|
| Last name | |
| First name | |
| Address | |
| Mail address | |
| Telephone number | |
| Tag nr. | |
| Age: 18+ | ☐ |
| Padi or dive cert. | ☐ |
| Lionfish hunting course | Other |
| Resident | Yes |
| Nr. ELF | |
| Property of | STINAPA |
| Deposit paid $ 150 | ☐ Date _____ |
| ELF returned | Date |
| Deposit returned | ☐ |

Notes 1. Please notify STINAPA 2 days in advance before returning ELF, this to make sure we have the funds available to return the deposit.

2. For repairs, please contact Bas Tol by phone number 7864917 or email bas@basdiving.com. All costs for repair need to be paid directly to Bas Tol.