Darwin Initiative to Enhance an Established Marine Protected Area System, Cayman Islands

Quantifying the Impact of Recreational and Artisanal Fisheries in the Cayman Islands

Interim Report, April 2011

Report prepared by the School of Ocean Sciences, Bangor University, Wales, in collaboration with the Department of Environment, Cayman Islands.

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Citation: Meier R.E., McCoy C., Richardson L. & Turner J.R. (2011) Quantifying the impact of recreational and artisanal fisheries in the Cayman Islands, through the use of socio-economic questionnaires. *Darwin Initiative Interim Report*. 104 pp.

Photo (front page): Young sports fisher at Morgan's Harbour, Grand Cayman (R. Meier).

ABSTRACT

Fishing is considered to be a major form of exploitation on many of the word's coral reefs, and numerous coastal communities rely on the food source and incomes supplied by their fisheries. As the global population continues to expand, overfishing becomes an intensified threat to coral reefs, and has the ability to significantly alter these valuable ecosystems. To examine the potential impact of recreational and artisanal fisheries on reef ecosystems in the Cayman Islands (where there is no commercial fishing), the level of fishing pressure was investigated. Structured socio-economic questionnaires were directed at fishers on Grand Cayman, Cayman Brac and Little Cayman, during February and March 2011, from a variety of survey locations. Information was collected on catch size, target species, fishing effort and the spatial distribution of fishing activities. The views of fishers on the marine environment, and designated marine protected areas around the islands, were also gauged through a series of multiple-choice questions.

Within a monthly period, fishers reported catching a total of 14,968 fish on Grand Cayman and 5205 fish on the Sister Islands (88% and 80% of which were reef fish, respectively). The mean catch size was 72 (±SD 152) fish month^{-1} on Grand Cayman, and catch size was significantly higher for respondents targeting reef fish than for those targeting pelagic species (Mann-Whitney *U* test, $P < 0.01$). The mean number of days spent fishing month^{-1} ranged between 5.1 (±SD 6.5) and 8.4 (±SD 7.4) on the three islands, and of the fish caught, Lutjanids were targeted in greatest numbers by all three fishing communities. Fishing effort was non-uniformly distributed around the islands (Chi-square tests, $P < 0.01$) and was fairly restricted to key areas, which around Grand Cayman, aligned closely with fringe reefs, heavily populated areas and major shore access points. On Cayman Brac and Little Cayman, effort was predominantly distributed off the east and west ends of the islands, where fishers reported following the reef edge and shelf drop-offs to fish. Marine enforcement officer reports spanning 1993-2010 were compiled to allow investigation of illegal fishing practices occurring on the Cayman Islands. Results indicate that poaching in the MPAs and other illegal fishing activities remain an issue, with the queen conch (*Strombus gigas*) representing the major target organism. Despite major support for the idea of marine environmental management, over 50% of interviewed fishers believed that enforcement of marine park laws is currently inadequate. This study provides a step toward determining the level of pressure on reef ecosystems from non-commercial fisheries. Despite lack of attention afforded to artisanal and recreational fisheries, this study indicates that both practices are significant in the Cayman Islands, with the potential to influence reef resilience and ecosystem functioning, in an environment in the Caribbean known to be experiencing existing stress from the effects of climate change and pollution. Current attitudes of fishers identified through this work suggest the need for future efforts to educate locals on the benefits of resource management, and a requirement for additional steps to improve relations between resource users and managers. Further socioeconomic considerations for management are discussed.

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1 INTRODUCTION

Photo: Grand Cayman boat access point (R. Meier)

1.1 Background to Reef Fisheries and MPA Management

Coral reef ecosystems are highly valuable in terms of the goods and services that they provide on environmental, economic and social scales (Bellwood et al. 2004), yet they are currently under extreme pressure, globally, from the threats of climate change, pollution, disease and overfishing (McClanahan et al. 2002; Hughes et al. 2003; Gardner et al. 2003, Wilkinson, 2008; Hughes et al. 2010).

Fishing is considered to be a major form of exploitation on many of the world's coral reefs, and numerous coastal communities in the tropics and subtropics rely on the food source and incomes supplied by their fisheries (Roberts, 1995; Jennings & Polunin, 1996a). Drastic increases have recently occurred in reef-based fisheries (Bellwood et al. 2004), and as the global population continues to expand, overfishing becomes an intensified threat to coral reefs (Hughes, 1994). Fishing has the potential to significantly impact coral reef ecosystems by causing reductions in the abundance, biomass and size of reef organisms, habitat degradation, genetic changes, loss of functional groups and overall changes to ecosystem structure and function (Jennings & Polunin, 1996a; 1996b; Jackson et al. 2001; Friedlander & DeMartini, 2002; McClanahan et al. 2002; Pauly et al. 2002; Hawkins & Roberts, 2004; Graham et al. 2005).

Photo: Local fishing boats on the shore, Grand Cayman (R. Meier).

There is evidence to suggest that overfishing in reef habitats can lead to ecological phase-shifts, resulting in loss of coral and overgrowth of macroalgae (McClanahan et al. 2002; Hughes et al. 2003; Bellwood et al. 2004; Hawkins & Roberts, 2004). In the Caribbean, widespread deterioration of coral reefs has been well documented over the past two decades, as have increases in reef fisheries (Roberts & Polunin, 1993; Hughes, 1994; McClanahan & Muthiga, 1998; Precht et al. 2002; Gardner et al. 2003; Coelho & Manfrino, 2007; Wilkinson, 2008). An observed shift from a coral dominated system to macroalgal dominance has been attributed largely to loss of grazing pressure, caused by overfishing of herbivorous reef fish species and pathogen-induced mass mortality of the urchin *Diadema antillarum* in the 1980s (Lessios et al. 1984; Hughes, 1994; Pinnegar et al. 2000), and elevated nutrient levels. Loss of functionally important predatory fish is also known to effect reef ecosystem functioning (Dulvy et al. 2004). The contribution of overfishing to such events highlights the sensitivity of reef ecosystems to extractive activities, and the need for effective fisheries management in reef environments (Bellwood et al. 2004).

While the impacts of intensive fishing practices are well recognised, artisanal fisheries are often considered to have less influence on the environment and as a result can be overlooked (Hawkins & Roberts, 2004). Studies focused on this form of fishing practice and on recreational fisheries suggest, however, that both are capable of contributing significantly to declining fish stocks and to ecosystem alterations (Bellwood et al. 2003; Cooke & Cowx, 2004; 2006, Hawkins & Roberts, 2004; Mangi & Roberts, 2006), and should subsequently be viewed with greater management concern.

Marine Protected Areas (MPAs) have become heavily utilized conservation tools in tropical marine ecosystems, and a means of managing reef fisheries in localized areas (Gell & Roberts, 2003; Halpern, 2003; Russ et al. 2004; Roberts et al. 2005, Hughes et al. 2010). Many existing studies have documented the benefits of MPAs, including evidence for increased biomass and density of targeted fish species, and positive effects on body size, reproductive potential, species diversity and community structure of organisms within reserve boundaries (Roberts et al. 2001; Gell & Roberts, 2003; Halpern 2003; Lester et al. 2009). In light of the significant global issues threatening reef ecosystems, MPAs are considered by many to hold great potential as a method of helping to conserve coral reefs and maintain reef resilience, despite providing no direct protection from climate change (Hughes et al. 2003; 2010; Roberts et al. 2005). However, past MPA failures have emphasized that appropriate design, implementation and management of these tools is paramount to success, as is the need for socio-economic considerations, such as levels of stakeholder involvement and education (Pollnac et al. 2001; McClanahan et al. 2005; Camargo et al. 2009; Hughes et al. 2010; Pollnac et al. 2010).

The use of MPAs in reef ecosystem management has been adopted in many areas of the Caribbean (Williams & Polunin, 2000; Spalding et al. 2001; Coelho & Manfrino, 2007; Mumby et al. 2007; Camargo et al. 2009), among which include the Cayman Islands, where a zoning system of Marine Protected Areas has been established and enforced for 25 years.

1.2 Reef Ecosystems and Fisheries of the Cayman Islands

The Cayman Islands are a UK Overseas Territory consisting of three West Indian Islands (Grand Cayman, Cayman Brac and Little Cayman) located in the Caribbean Sea, to the south of Cuba and west of Jamaica (Geographical position: 19 degrees north and between 79-82 degrees west, Figure 1) (Davies, 1994). The resident population of the Cayman Islands was recently estimated at 54,878 individuals (ESO, 2010), although the many tourists that visit the island each year (Spalding et al. 2001) further elevate this number.

Fringing reefs are situated around the Cayman Islands, containing shallow reef crests and two discrete reef terraces (Spalding et al. 2001; Pattengill-Semmens & Semmens, 2003; Wilkinson, 2008). Lagoonal patch reefs, mangroves and seagrass beds are other prominent marine habitats of the Islands, which contribute to supporting a diversity of invertebrates, fish, turtles and megafauna (Burgess et al. 1994). The shelf is narrow around the Cayman Islands, and seldom reached widths of more than 1.5km on Grand Cayman (Spalding et al. 2001). Concerns exist about the capacity of reefs and associated ecosystems in the Cayman Islands (as elsewhere in the Caribbean) to deal with coral bleaching, ocean acidification, sea level rise and continued disturbance from hurricanes, combined with additional pressures from fisheries, tourism and coastal development. Tourist-related development is considered a major pressure on the reefs and past declines in stocks of reef fish have been associated with fishing activities (Spalding et al. 2001). Potential overfishing has further been stated as the largest threat to fish in the Cayman Islands (Burgess et al. 1994).

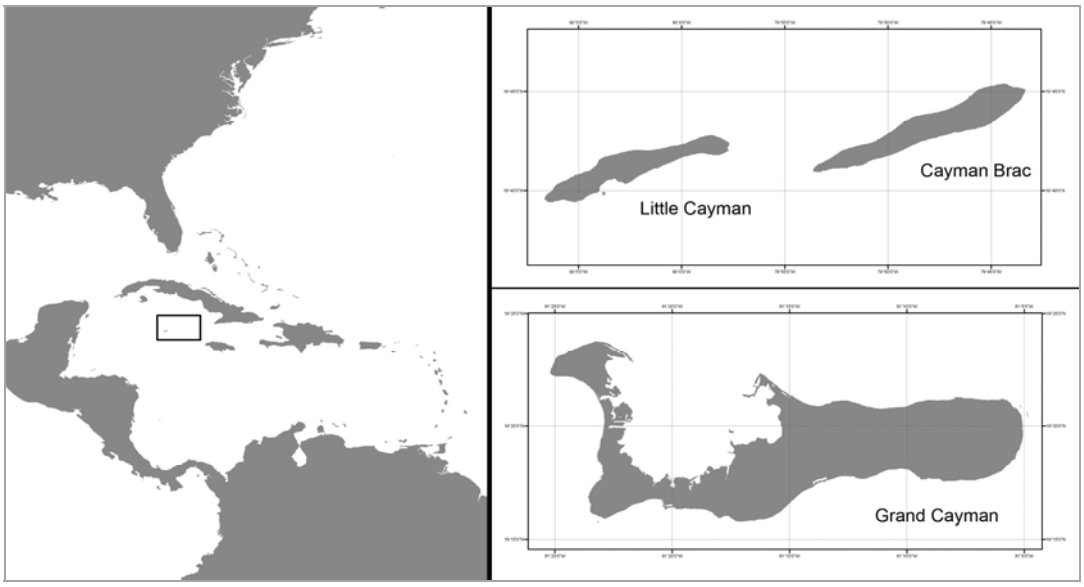


Figure 1. Location map of the Cayman Islands, within the wider Caribbean Sea.

Over 380 species of fish and elasmobranchs are known to occur in Caymanian waters, either on a migrational basis or year round (Burgess et al. 1994). Frequent inhabitants of the reefs include snappers, grunts, parrotfish, surgeonfish, jacks, groupers, triggerfish, squirrelfish and barracuda, many of which represent valuable economic draws through the dive industry.

No major commercial fishery exists on the Cayman Islands, however, both artisanal and recreational fishing does occur, and existing information, although limited, indicates that these activities are marked (Henshall, 2009). Traditionally, many Caymanians relied on fishing for their livelihood or as a food source, and today some residents continue to catch fish as a method of income, using techniques such as hook and line, cast netting and fish traps (Burgess et al. 1994). Fishing for sport is a notable recreational activity on Grand Cayman, and a number of fishing charter companies operate out of the island and contribute to the economy. In 1994 for example, sports fishing supplied $1 million in economic revenue (Burgess et al. 1994). Common target species of inshore fishers include triggerfish, jacks, snappers, grunts, parrotfish, grouper, barracuda, tarpon and bonefish, while offshore species include wahoo, dolphin, yellowfin tuna, marlin and sailfish (Burgess et al. 1994).

Image: Artisanal fishers gutting cleaning catch on Cayman Brac (L. Richardson).

In June – July 2009 a pilot study was undertaken on Grand Cayman (Henshall, 2009), to trial the use of socio-economic questionnaires on fishers, for quantification of recreational and artisanal fisheries on the island. Fishers reported catching a significant number of fish (11,140) during a monthly period, 87% of which were reef fish, including important herbivorous species. Fishing effort was also notable, with a mean of 5.3 days (± SD 6.4) spent fishing per fisher month^{-1} (Henshall, 2009), accentuating the need for effective conservation measures in Caymanian waters.

A series of Marine Parks have been in place around the Cayman Islands since establishment in 1986, under the Cayman Islands Marine Conservation Law of 1978 (Davies, 1994), and the current MPA network covers 16.7% of the Cayman shelf. Three types of marine reserve were initially designated: **Marine Park Zones**, **Replenishment Zones** and **Environmental Zones,** where various forms of restriction apply on the taking of marine life, anchoring and boating (see Appendix 1 for full marine park regulations and conservation laws). Further purpose-specific zones have been established around the islands, since that time, including **Grouper Spawning Areas**, **No Dive Zones** and **Wildlife Interaction Zones** to regulate tourist activities at the Sand Bar and Stingray City (Davies, 1994). Closed seasons operate for lobster, conch, whelks and Nassau grouper, both catch and size limits are in place, and various licensing restrictions apply (Appendix 1).

Seven full-time marine fisheries officers are employed by the Department of Environment (DOE) on Grand Cayman to patrol the waters around the marine parks and actively enforce the marine park restrictions during daylight hours, and a singular officer on each of the two Sister Islands (Cayman Brac and Little Cayman) is responsible for enforcement. While officers liaise with the police force, they themselves currently hold no powers of arrest, and poaching still occurs in the MPAs.

Despite regular monitoring of the Marine Parks on the Cayman Islands by the DOE, no comprehensive scientific review of the MPA system has been carried out since its implementation in the 1980s. The human population has expanded greatly since establishment of the marine reserves in the mid-1980s (Spading, 2001), and diving, ecotourism and boating are popular activities for tourists and residents alike. Recent preliminary studies performed by the DOE and School of Ocean Sciences (SOS), Bangor University, have found evidence to suggest the occurrence of a phase-shift from a coral to an algal dominated system around the Cayman Islands, and differences in algal cover, coral cover and fish biomass inside and outside of the MPAs have been detected (Gall et al. in submission; McCoy et al. 2009; Campbell, 2010). However, future more extensive studies are still warranted to determine the effect of the MPAs on reef resilience, and the impact of activities such as fishing on the reef ecosystems of the Cayman Islands.

1.3 Project Aims

This study was undertaken as part of a wider Darwin Initiative funded project, run through collaboration between the School of Ocean Sciences, Bangor University (SOS) and the Department of Environment, Cayman Islands (DOE). The project, entitled 'Darwin Initiative to Enhance an Established Marine Protected Area System, Cayman Islands' began in 2010, after receiving a Darwin Initiative grant, and is funded until 2013. The primary object of the project is to assess the effectiveness of the current marine protected area system of the Cayman Islands in maintaining ecosystem resilience, with a wider purpose of 'ensuring coastal protection for human settlements and future tourism income by enhancing the protection of coral reefs, thereby allowing rehabilitation of supporting ecosystems, through increased resilience to climate change'. Studies are being carried out to compare biotic measures such as coral cover, coral health, algal biomass and fish abundance, within and outside of the MPAs, The extent of overspill of fish biomass from the No-Take zones, and mapping of the reef and associated subtidal ecosystem habitats around the three islands are also on-going.

The main aim of this study, within the context of the wider project, was to assess and quantify artisanal and recreational fisheries on Grand Cayman, Cayman Brac and Little Cayman, through structured socio-economic questionnaires directed at fishers on the three islands, in order to identify the extent of non-commercial fishing pressure and the likely associated impacts on ecosystem functioning and MPA effectiveness. The study follows on from a pilot survey carried out in 2009 on Grand Cayman (Henshall, 2009), and aims to continue addressing the gaps in knowledge that exist regarding fishing pressure, while providing information that can be applied to management.

Specific study aims were to:

i) Quantify fishing pressure by obtaining data on catch size, main target species, monthly fishing effort and the spatial distribution of fishing activity.

ii) Determine the views of the fishing population, and the socio-demographic factors influencing these views, in order to better understand current feeling towards the marine parks and any future opposition that may arise from changes in the MPA system.

iii) Quantify fishing pressure exerted by tourists visiting the Cayman Islands and determine the level of awareness of marine management held by this group.

iv) Compare data on non-commercial fishing pressure attained in the current survey with data from a pilot survey undertaken in 2009, as a means of making a preliminary investigation of temporal and seasonal differences in fishing pressure.

v) Quantify illegal fishing between 1993-2010, through analysis of DOE fisheries officer incident reports and legal case files.

2 METHODOLOGY

Photo: Grand Cayman charter boat captain taking part in survey (M. Orr)

2.1 Data Collection

Structured socio-economic questionnaires were conducted in and around the Cayman Islands during February and March 2011, to obtain quantitative information on fishing pressure around the Islands. Survey durations on the Sister Islands consisted of one-week periods: surveys were conducted on Cayman Brac from the 6th – 10th February and on Little Cayman between 24-28th February. Questionnaires were undertaken on Grand Cayman over a longer six-week period between 16th February and 30th March.

Questionnaires were directed at recreational fishers, artisanal fishers and visiting tourists partaking in fishing activities on the three islands. Face-to-face surveys were conducted from land at a range of locations, which included boat launch areas, yacht clubs, harbours, fish markets, marine supplies stores, restaurant bars, beach resorts, the shore, and during an organised fishing tournament on Grand Cayman. Questionnaires were also directed at individuals that were partaking in fishing activities on the water, from Department of Environment patrol vessels. Individuals that participated in the survey included local residents, tourists, ex-patriots, charter boat operators and migrant workers. Additional surveys were sent remotely to civil servants working within the Cayman Island Government during March and April 2011.

Photos (left to bottom right): Fisher surveys at a local boat ramp (L. Richardson), fish gutting station (R. Meier), and the Grand Cayman fish market (R. Meier).

The questionnaires used in this study were adapted from those originally designed in an MSc Thesis project that took place on Grand Cayman in 2009 (Henshall, 2009). Questionnaires were approved by the Bangor University Ethics Committee prior to fieldwork and were adapted after an initial pilot project phase in 2009, which was undertaken to refine question structure and ensure ease of statement interpretation by the survey respondents (Henshall, 2009). The majority of the questionnaire consisted of multiple-choice questions, and the survey was divided into three sections. The first section related to the characteristics of participant fishing activities, to include information on fishing effort, the spatial distribution of fishing activities, catch size and target species. Survey respondents were asked to specify the number of days that they had fished during the month prior to the survey and the number and type of fish that they had caught during that time, as well as indicate, on a gridded map, the locations in which they had fished during the last month. The views and opinions of fishers were gauged through a section of questions related to the perception of participants on the state of the marine environment, temporal changes in fish populations, and views on the current effectiveness and appropriateness of marine environmental management around the Cayman Islands. Fishers were asked to state whether or not they agreed with a series of opinion statements about the marine environment and management, and were further asked their views in the form of an open ended question. The final section of the questionnaire was developed to investigate the socio-demographics of the surveyed population, by collecting information on gender, age, nationality, length of residency and occupation (see Appendix 2 for full details of the questionnaires).

2.2 Data Analysis

Non-parametric univariate statistical tests were performed using the software package SPSS (v14), to investigate the influence of fisher characteristics on fish communities around the Cayman Islands. To compare median levels of fishing pressure exerted by different groups of fishers (boat versus shore fishers, reef versus pelagic fishers and Caymanian versus non-Caymanian fishers), Mann-Whitney *U* tests were performed on Grand Cayman fish catch data (the number of fish caught per fisher day^{-1}), fishing effort data (the number of days spent fishing month^{1}) and catch per unit effort data (CPUE: the number of fish caught per fisher day^{-1}). Limited statistical analysis could be applied to the Cayman Brac data due to low levels of replication and no statistical analysis was possible for the Little Cayman dataset for this reason. Chi-square tests were performed on arcsine square-root transformed proportion data to investigate the influence of nationality on the primary reason that respondents fished, and differences in respondent ratings of the condition of the marine environment were tested using Kruskal-Wallis tests.

Data on the spatial distribution of fishing around the three study islands were imported into ArcView GIS software, to allow visual representation of fishing pressure. The fishing pressure in each map grid square was calculated based on the number of survey participants visiting an individual square in a month, and data was sorted into frequency bins to allow a graded representation of

the level of fishing pressure in each square. The influence of targeted fish type and fishing platform on the spatial distribution of fishing effort on the survey map was statistically tested using Chi-square tests on arcsine square-root transformed proportional data (representing the proportion of total respondent map square visits, for each individual square).

Multivariate community analysis was performed using the PRIMER v6 software package, to investigate the affects of different fisher characteristics (targeted fish type & fishing platform) on fish catch community structure, and of different socio-demographic factors on the views of fishers. Cluster analysis was undertaken on the fish community data caught by survey respondents, arranged at the family level, using a Bray-Curtis index of similarity on √-transformed data. The multiple choice opinion statements (survey question 11,12 and 16) were analysed in a similar way, to allow investigation of the similarity in views between various fisher groups. From the resulting similarity matrices between every pair of survey respondent samples (Clarke & Ainsworth, 1993), multidimensional scaling (MDS) was performed and MDS ordination plots were produced allowing a 2-dimensional representation of the patterns between fishers. The one-way analysis of similarities (ANOSIM) test was performed to test the statistical difference in community abundance between i) fisher characteristics (fish type targeted and fishing platform), and ii) fisher demographics (gender, age, nationality, occupation, length of residency and fishing frequency). SIMPER analysis was subsequently carried out on both fish abundance and opinion data, allowing important discriminator species to be identified in terms of the percentage contribution of a species (fish or opinion statements) to the overall dissimilarity between groups.

To investigate temporal variation in fishing pressure, data collected during the current study was compared with data from a pilot study carried out on Grand Cayman in 2009 (Henshall, 2009). Chi-square tests were performed on arcsine square root transformed proportion data to examine whether the total catch of different fish families varied between the two surveys and whether the primary reasons for fishing differed. To investigate whether median fishing effort (days spent fishing), catch size and CPUE differed between survey years, Mann-Whitney *U* tests were performed. DOE Marine Fisheries Officer illegal incident reports spanning 1993-2010 were also compiled and analysed.

Photo: Artisanal fishers at fish gutting station, Spot Bay, Cayman Brac (R. Meier).

3 RESULTS

3.1 GRAND CAYMAN

Photo: Local fisher's catch, Cayman Brac (R. Meier)

3.1.1 Fishing Pressure

A total of 275 resident questionnaires were conducted on Grand Cayman from 29th February – 30th March 2011, 264 of which were used for analysis of fisheries quantification. The 11 questionnaires that were excluded from further analysis were those not deemed reliable after the face-to-face survey using a pre-determined criterion. All completed questionnaires were used for analysis of fishers' opinions.

36 of the survey participants had not engaged in fishing activities during the month prior to the time in which the survey was conducted. Survey respondents that had fished, reported a total catch of 14,968 fish, 1128 conch and 378 lobsters during a monthly period. Of those fishers than engaged in fishing activities during the month prior to the survey, the mean reported catch was 72 fish (± SD 152) per person month^{-1} (n = 228). 13,220 reef fish (88% of total fish caught) and 1370 pelagic species (9% of the total) were caught during the month prior to the surveys. 378 fish classed as 'other', which included fish such as tarpon, bonefish, snook, herring and Spanish mackerel, known to inhabit either sand flats, brackish waters or nearshore shallows, were also reported as landed. However, fishers reported releasing the majority of gamefish (tarpon, bonefish and snook).

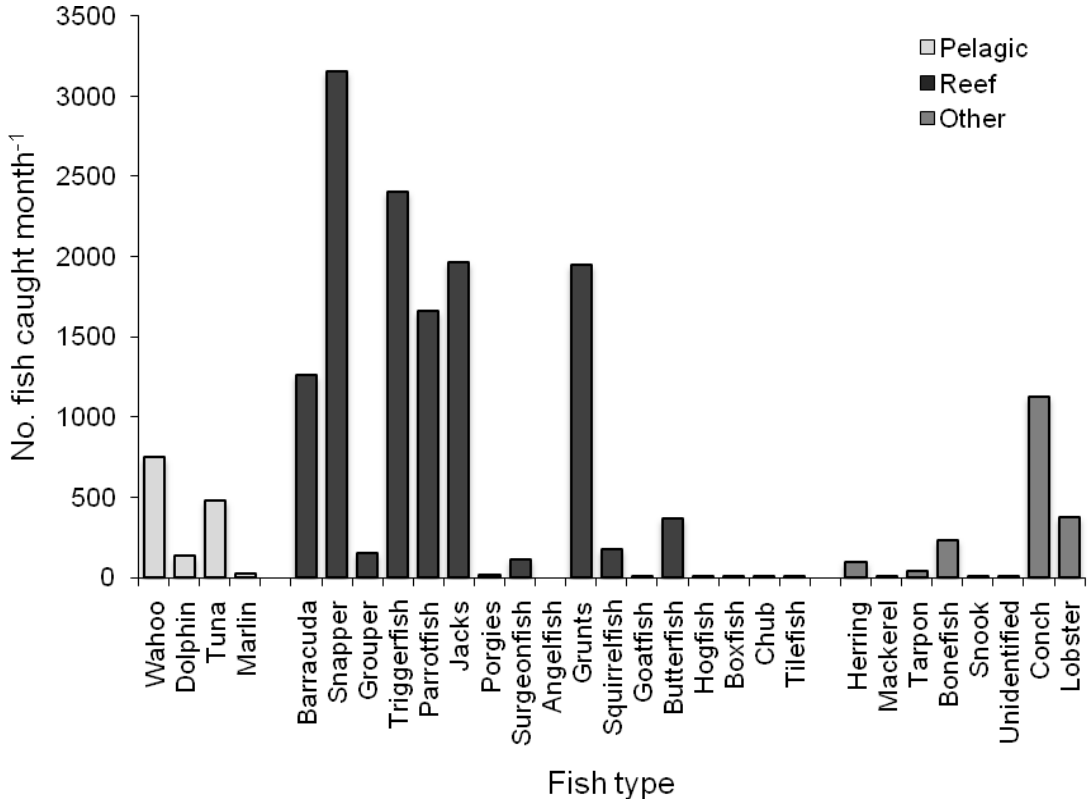


Figure 2. Quantities of fish, conch and lobster caught by survey respondents around Grand Cayman, during a monthly period (n= 228). Light grey bars = pelagic species, dark grey bars = reef species, mid grey bars = 'other' species.

Snappers (family: Lutjanidae) were the reef fish species targeted by fishers in greatest numbers (3155 fish) (Figure 2), with yellowtail (*Ocyurus chrysurus*), mangrove (*Lutjanus apodus*) and mutton snappers (*Lutjaus analis*) frequently mentioned. Other reef species regularly caught included triggerfish (Namely *Balistes vetula* and *Canthidermis sufflamen*), parrotfish (family: Scaridae), jacks (family: Carangidae) and grunts (family: Haemulidae) (Figure 2).

The median number of fish caught by fishers during a monthly period was significantly higher for respondents targeting reef fish than for those fishing for pelagic species (Mann-Whitney *U* test, $U = 690.0$, $P = 0.001$) (Table 1). Boat fishers reported significantly larger median fish catches, than those respondents that fished entirely from shore (Mann-Whitney *U* test, $U = 1745.0$, $P = 0.008$), as did those survey participants fishing from a mix of platforms (Mann-Whitney *U* test, $U = 476.0$, $P = 0.001$) (Table 1). Catch size differed significantly between Caymanian and non-Caymanian fishers, with the latter catching a significantly smaller median number of fish (Median catch size: Caymanian fishers = 31.0, non-Caymanian fishers = 14.5) (Mann-Whitney *U* test, $U = 4365.5$, $P = 0.001$). The fish community structure caught by survey respondents was also significantly different between boat, shore and mixed platform fishers (ANOSIM, $R = 0.116$, $P < 0.001$) (Figure 3). Post-hoc testing revealed the differences to lie between shore fishers and the other two categories ($P < 0.001$), and SIMPER analysis indicated that snapper was the fish group that contributed most to the dissimilarity between the three groups (Appendix 3).

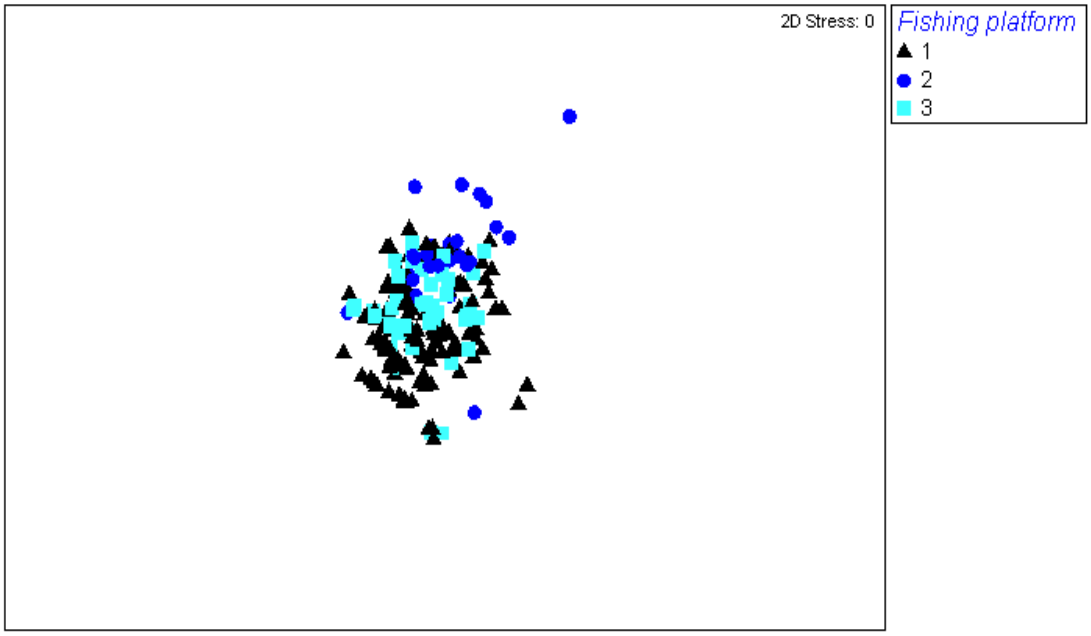


Figure 3. MDS ordination plot representing the 2-dimentional similarities between the fish community caught by respondents fishing from different platforms on Grand Cayman (1 = boat, 2 = shore, 3 = mixed) (n = 221).

Table 1. The total number of fish caught, number of days spent fishing, and Catch Per Unit Effort (CPUE = number of fish caught per day) of survey participants on Grand Cayman during a monthly period prior to the time that surveys were conducted. Data is present based on the type of fish landed (reef, pelagic and mixed species catches) and the fishing platform (boat, shore and mixed). Mean (± standard error) and median values are shown.

	Fish Type			**Fishing platform**		
	Reef	Pelagic	Mixed	Boat	Shore	Mixed
Total no. fish caught month^{-1}						
Mean	73.4	14.4	91.6	76.2	26.1	106.0
SE	± 15.4	± 37.1	± 16.0	± 11.8	± 5.8	± 32.9
Median	12.5	5.0	38.0	24	14	42
n	122	21	79	136	36	48
Fishing effort (days fishing month^{1})						
Mean	4.9	5.7	6.7	5.4	6.0	7.7
SE	± 1.3	± 0.6	± 0.8	± 0.5	± 1.2	± 1.2
Median	2.0	3.0	4.0	3.0	2.0	5.0
n	122	21	79	136	36	47
CPUE (no. fish day^{-1})						
Mean	12.1	3.2	16.3	13.5	5.1	16.1
SE	± 16.4	± 3.3	± 18.3	± 1.4	± 0.7	± 3.2
Median	7.0	2.0	10.0	8.3	4.2	5.6
n	122	21	79	136	36	48

SE = Standard Error, n = number of replicates

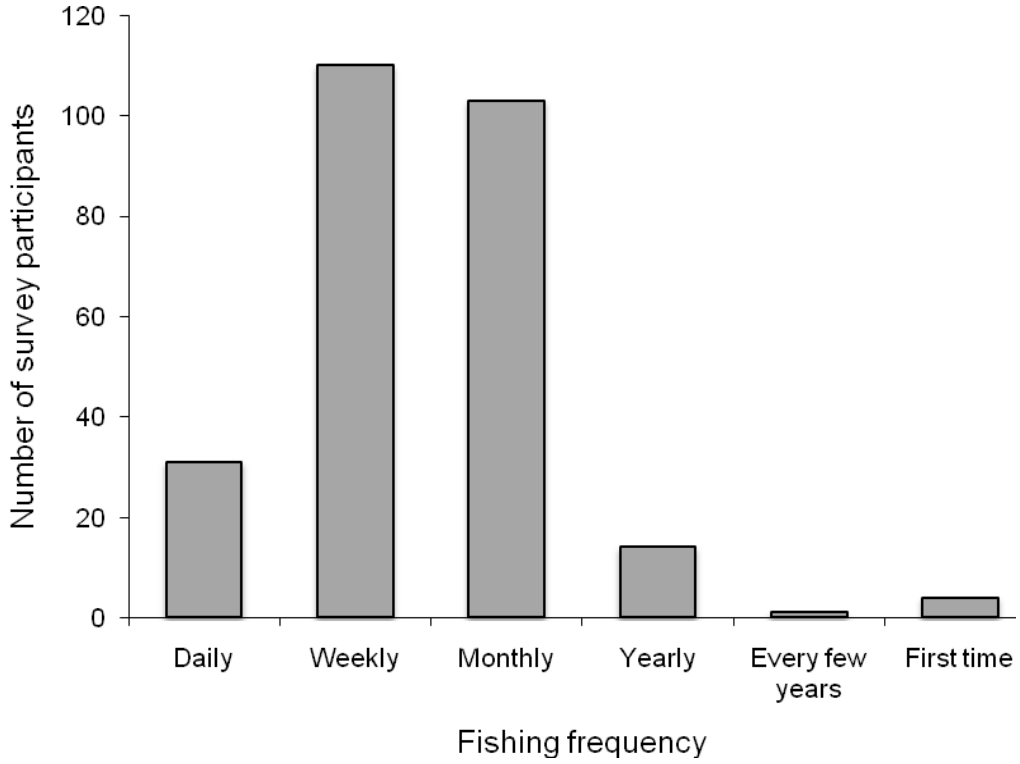
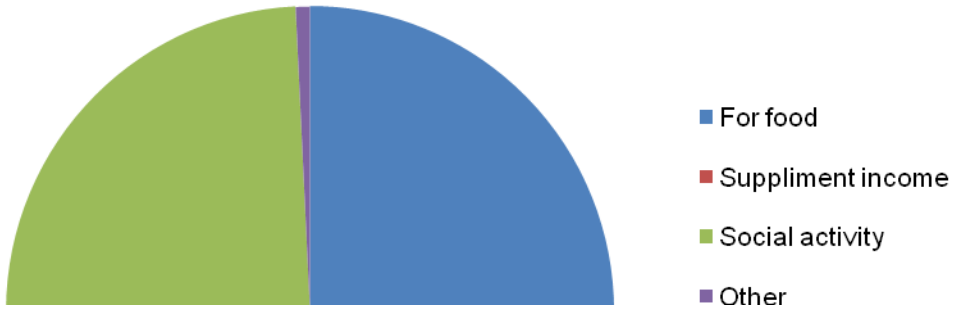


Figure 4. The distribution of Grand Cayman survey respondents, based on the frequency of occurrence of fishing activities around the island (n = 263).

The majority of respondents fished either on a 'weekly' or a 'monthly' basis (42% and 39%, respectively) (Figure 4), with a mean number of days spent fishing per month of 5.1 (± SD 6.5) (n = 264). The mean number of hours fishers spent with fishing gear deployed in the water was 5.5 (± SD 2.61), and on average on Grand Cayman, fishermen kept 74% (± SD 31.3) of their catch (n = 226). No significant difference was found in fishing effort (median number of days spent fishing per month) between those respondents fishing from shore and those fishing from boat platforms (Mann- Whitney *U* test, *U* = 2327.0, *P* = 0.645), or between fishers targeting reef fish and pelagic species (Mann- Whitney *U* test, *U* = 1101.0, *P* = 0.298) (Table 1).

The main reasons for fishing on Grand Cayman were 'for recreation' and 'for food', with 42% and 36% of respondents stating these as their primary motives (Figure 5a). 22% of respondents engaged in fishing practices to provide a source of income, and many individuals who chose this option stated that they sold fish to supplement their primary means of income or during periods when work was sparse. The majority of fishers reported fishing during mornings (62%), with many engaging in fishing activities early during Saturday and Sunday (Figure 5b). Evidence was found to suggest that nationality had an influence on the primary reason that respondents fished (Chi-square test, χ^2 = 6.591, df = 2, *P* = 0.037), with a greater proportion of Caymanian respondents fishing 'for food' or to 'supplement income' than non-Caymanian respondents (Figure 6).

a)



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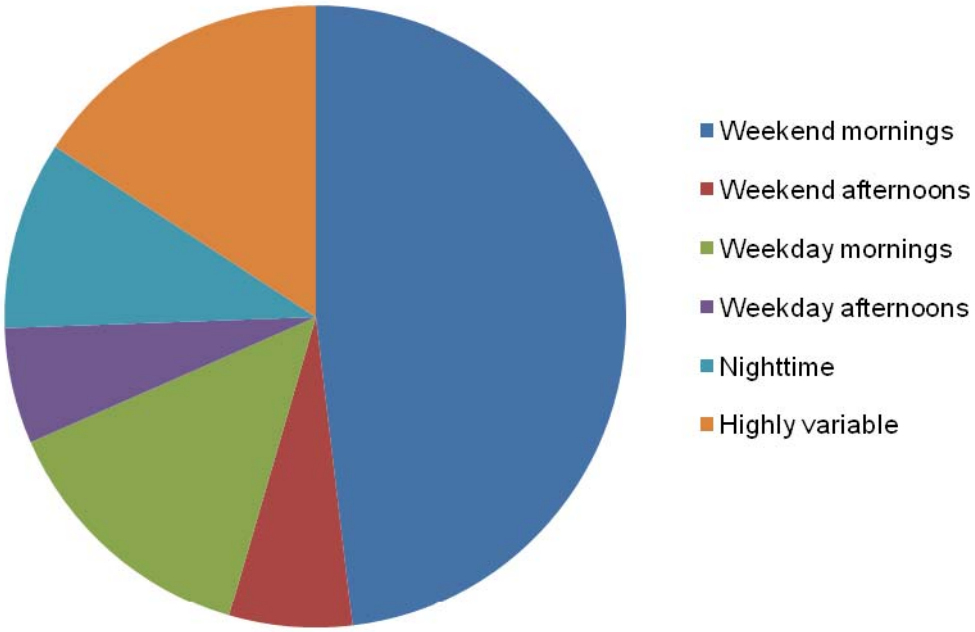


Figure 5. The proportion of Grand Cayman survey respondents represented in different categories based on a) the main reported reason for fishing (n= 262) and b) the time of day 'on average' that respondents fish (n = 264).

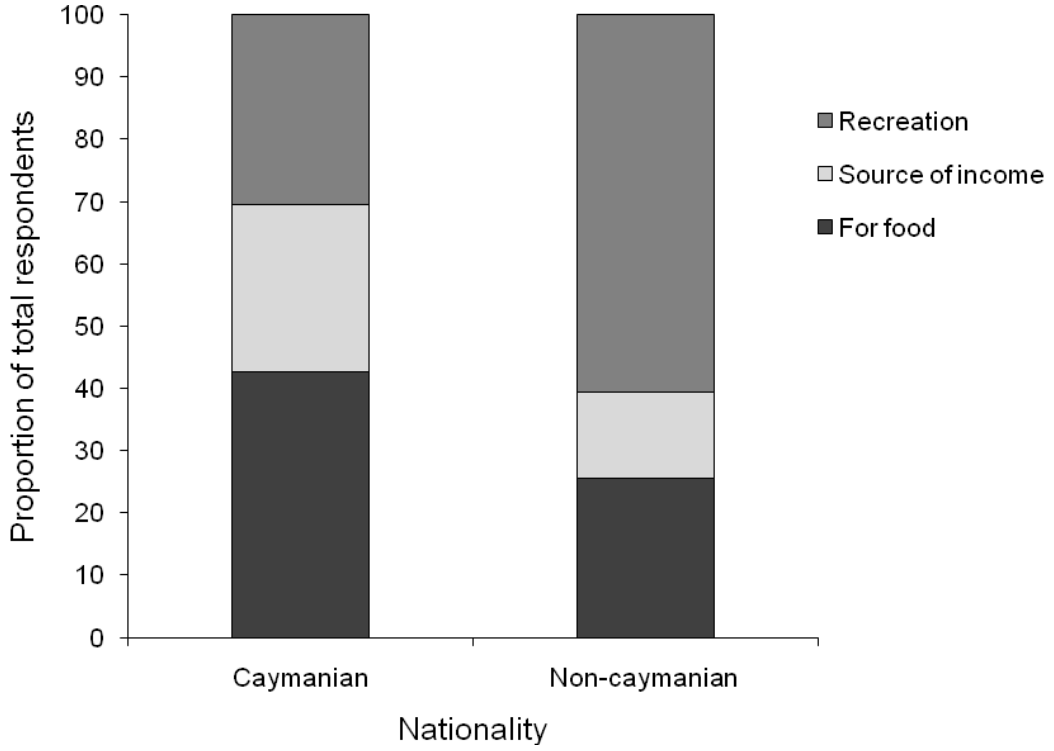


Figure 6. The proportion of total survey respondents represented in each category for the primary reason that fishers engaged in fishing activities on Grand Cayman (n = 260).

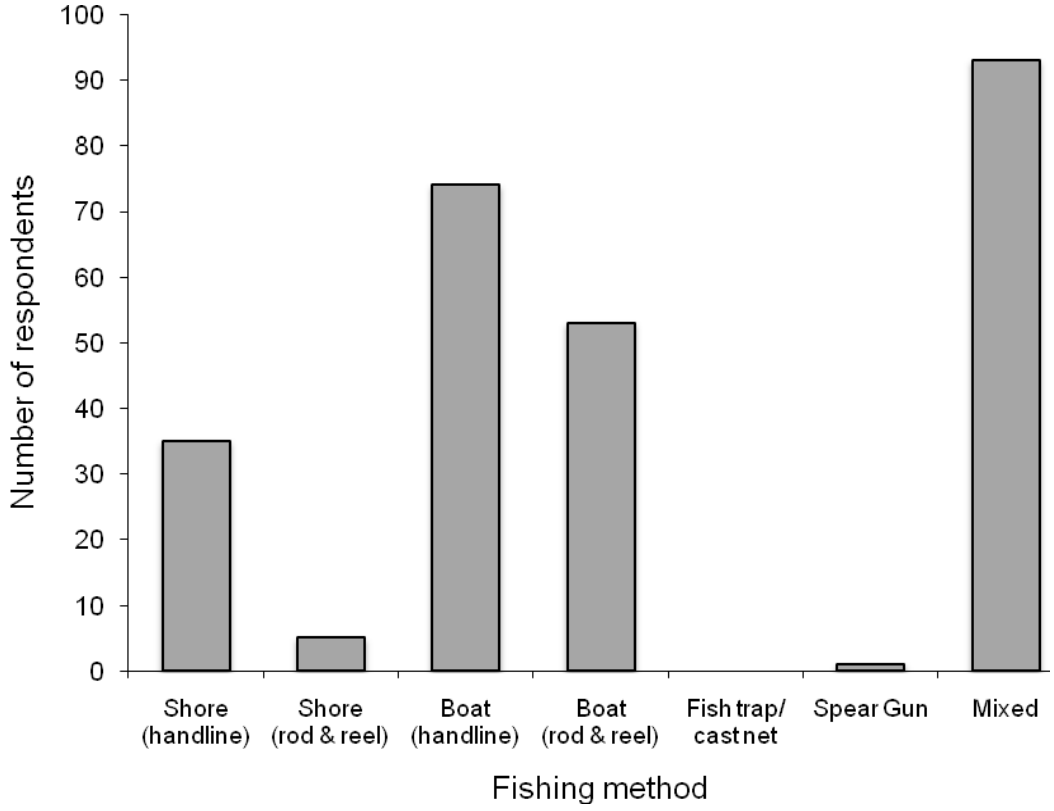


Figure 7. The frequency of survey respondents engaging in the different fishing methods used on Grand Cayman, as reported by fishers during fishing surveys in February and March 2011 (n = 261).

Survey participants fishing with mixed fishing methods were the most frequently encountered (35%) (Figure 7). Line fishing from boat platforms, either using traditional handline techniques or with rod and reel was also popular (28% and 20% respectively). Only one respondent reported spear gun fishing solely as a method to catch fish on Grand Cayman, although 8 fishers spear fished as one of many techniques (Table 2). 24% of survey respondents fished for reef species from boat platforms, and 24% of participants reported fishing from boats for both reef and pelagic fish (Table 2).

The total mean CPUE for all fish on Grand Cayman was 12.4 fish day^{-1} (± SD 16.6) (n = 228). Median CPUE of reef fish species was significantly higher than for pelagic species (Mann-Whitney U test, U = 599.0, P < 0.001), and a highly significant difference in CPUE was also found between boat and shore fishers, with those respondents fishing from boat reporting higher median CPUE (Mann-Whitney U test, U = 1506.5, P < 0.001) (Table 1). When data were further divided into the different fishing techniques reported by fishers, fishing effort was fairly evenly distributed in terms of the number of days spent fishing in a monthly period (Figure 8). CPUE was lowest for survey participants fishing from shore for reef fish species and from boats for pelagic species, but was fairly similar for all other fishing categories. CPUE differed dependent on Nationality, with Caymanian fishers catching a greater median number of fish per day (Median: Caymanian fishers = 7.5, non-Caymanian fishers = 5) (Mann-Whitney U test, U = 4586.0, P = 0.005).

Table 2. Definitions of different fishing techniques reported by fishers during fisheries surveys on Grand Cayman, and the number of fishers represented in each category (n = 246).

Fishing method	Abbreviation	Respondent no.
Fishing from boat for reef fish species	Boat/Reef	60
Fishing from boat for pelagic species	Boat/Pelagic	30
Fishing from boat for reef & pelagic species	Boat/Mixed	60
Fishing from shore for reef fish species	Shore/Reef	43
Fishing with spear gun for reef fish species	Spear gun	1
Fishing with mixed methods for reef species	Mixed/Reef	29
Fishing with mixed methods for mixed species	Mixed/Mixed	23

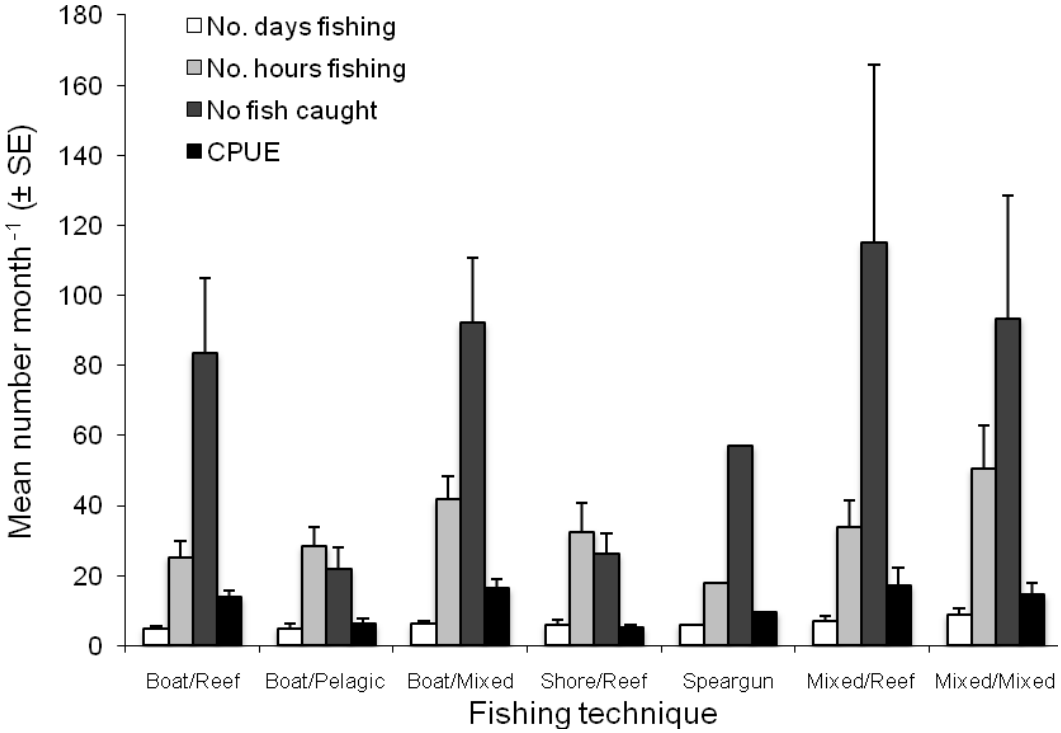


Figure 8. Fishing effort of survey respondents interviewed on Grand Cayman during February & March 2011, based on the fishing technique employed by fishers. The mean number of days and hours spent fishing per month, the mean number of fish caught per month and CPUE (the number of fish caught per day) are shown. SE = Standard error (n = 221).

The spatial distribution of fishing effort, in terms of the number of individuals visiting each map square, was not uniform around Grand Cayman (Chi-square test, χ^2 = 1380.09, df = 53, P <0.01). The waters that experienced highest fishing pressure during a monthly period were 12-mile bank, West Bay (mostly constrained to North West Point and the shore opposite the turtle farm), East End, the entrance to the North Sound, and South Sound (Figure 9). Of those fishers fishing around North West Point, 64% fished entirely from boat, while 20% fished only from shore. 65% of respondents fishing from East End (Map square 33, Appendix 4), and 70% of those fishing around South Sound, were boat fishers only.

As expected, the spatial distribution of fishing effort differed between respondents fishing from boat and those fishing from shore (Chi-square test, χ^2 = 164.16, df = 42, P <0.01), as well as between those targeting reef fish species and pelagic species (Chi-square test, χ^2 = 164.98, df = 42, P <0.01). A greater proportion of boat fishers visited 12-mile bank and East End, while shore fishers frequented North West Point, Barkers, Seven Mile Beach and the Jackson's Point area in greater proportions (Appendix 4). Spatial distribution patterns followed a similar pattern based on the type of fish targeted by respondents, with a greater proportion of pelagic fishers fishing at the Banks and East End, while reef fishers fished in greater proportions around North West Point, the entrance to the North Sound, Jackson Point and South Sound (Appendix 4).

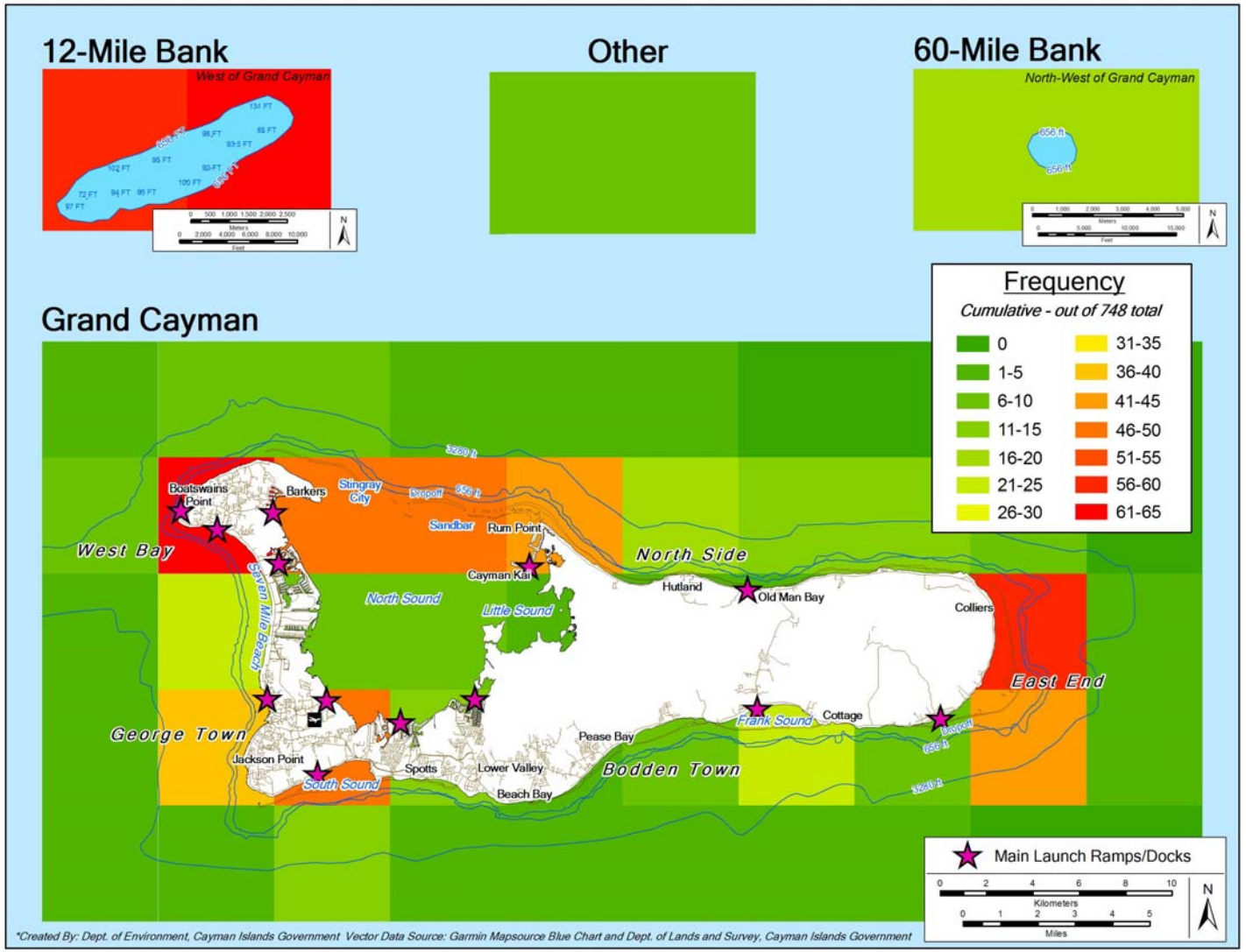


Figure 9. Spatial distribution of fishing effort over a monthly period on Grand Cayman, based on information provided by local residents, ex-patriots and tourists during socio-economic questionnaires performed on the island in February and March 2011 (n = 260). Star symbols show locations of the major boat launch areas.

3.1.2 Views and Opinions

Many survey participants held the opinion that the quantity of fish in their catch had changed over time on Grand Cayman (59%), 46% of which believed that abundance had 'decreased greatly' (Figure 10). In comparison, 60% of fishers believed that the size of fish in their catch had not changed, while 32% held the opinion that fish size had decreased, either slightly (16%) or greatly (16%).

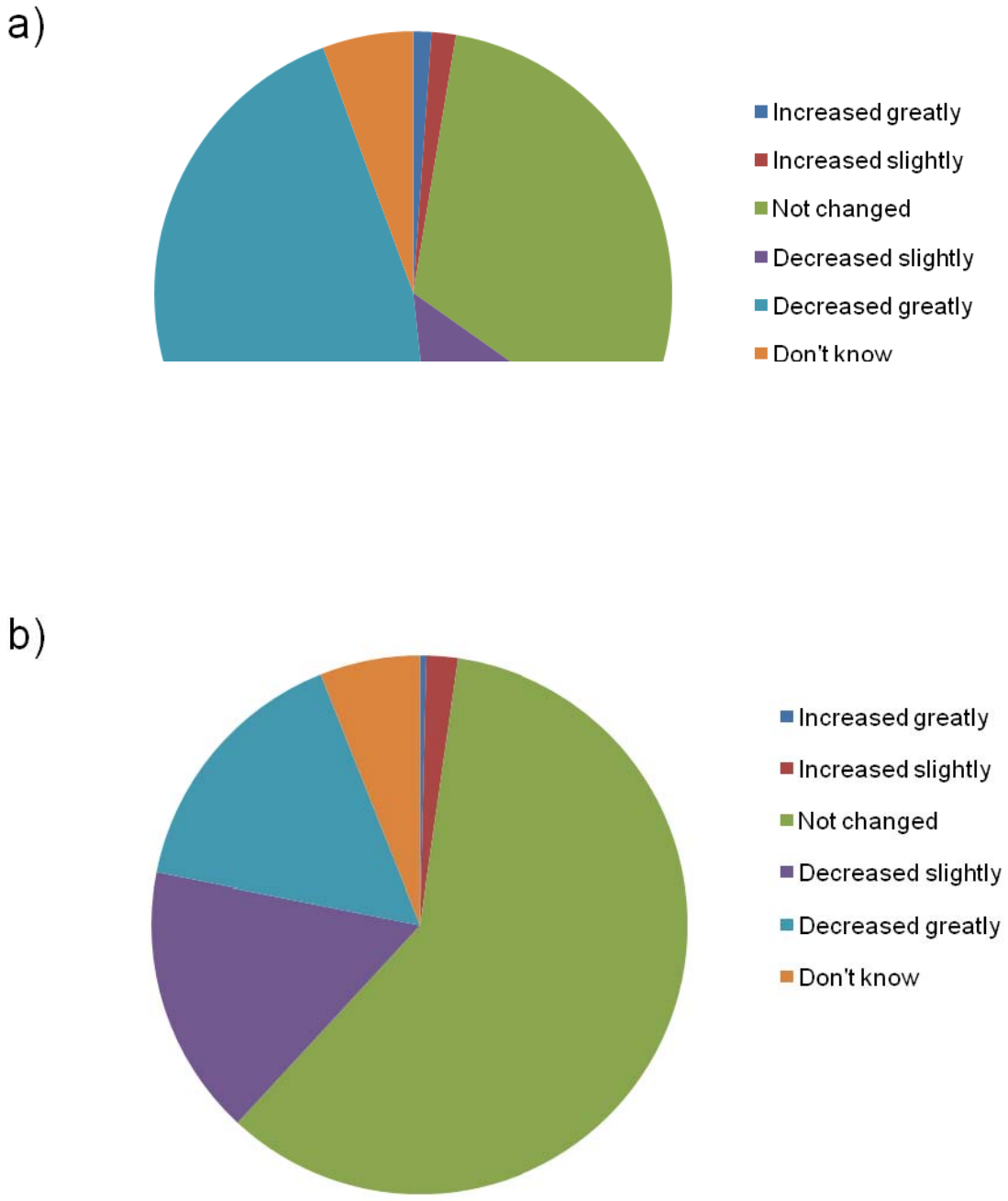


Figure 10. The opinions of Grand Cayman survey respondents on whether a) the average quantity of fish and b) the average size of fish in catches had changed over time. Surveys were conducted on Grand Cayman during February and March 2011 (n = 263).

Abundance of fish was the factor of greatest influence on the location in which fishers chose to fish (40% of the respondent's choices). Weather, tidal state and currents, as well as distance from home were further factors of influence frequently chosen by survey respondents (38% and 20% of choices, respectively) (Figure 11).

The mean response of survey participants, when asked to rate the condition of the marine environment around Grand Cayman on a scale of 1-10 was 7.3 (± SD 1.8), and 85% of targeted individuals rated the condition above 5 on the scale (n = 269). The median rating differed significantly dependent on respondent nationality (Kruskal-Wallis test, χ^2 = 8.871, *P* = 0.012). There was no difference in opinion between Caymanians and expatriates from outside of the Caribbean (Mann-Whitney *U* test, *U* = 3279.0, *P* = 0.128), however respondents that were born elsewhere in the Caribbean rated the marine environment in a better state around the Cayman Islands, than either of the other categories (Mann-Whitney *U* tests, *P* <0.05) (Figure 12).

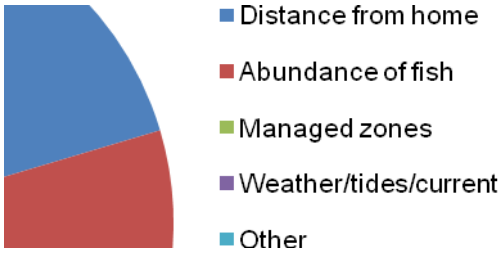


Figure 11. Proportional survey responses of Grand Cayman fishers, dependent on the main factors influencing the choice of location in which to fish (n = 260).

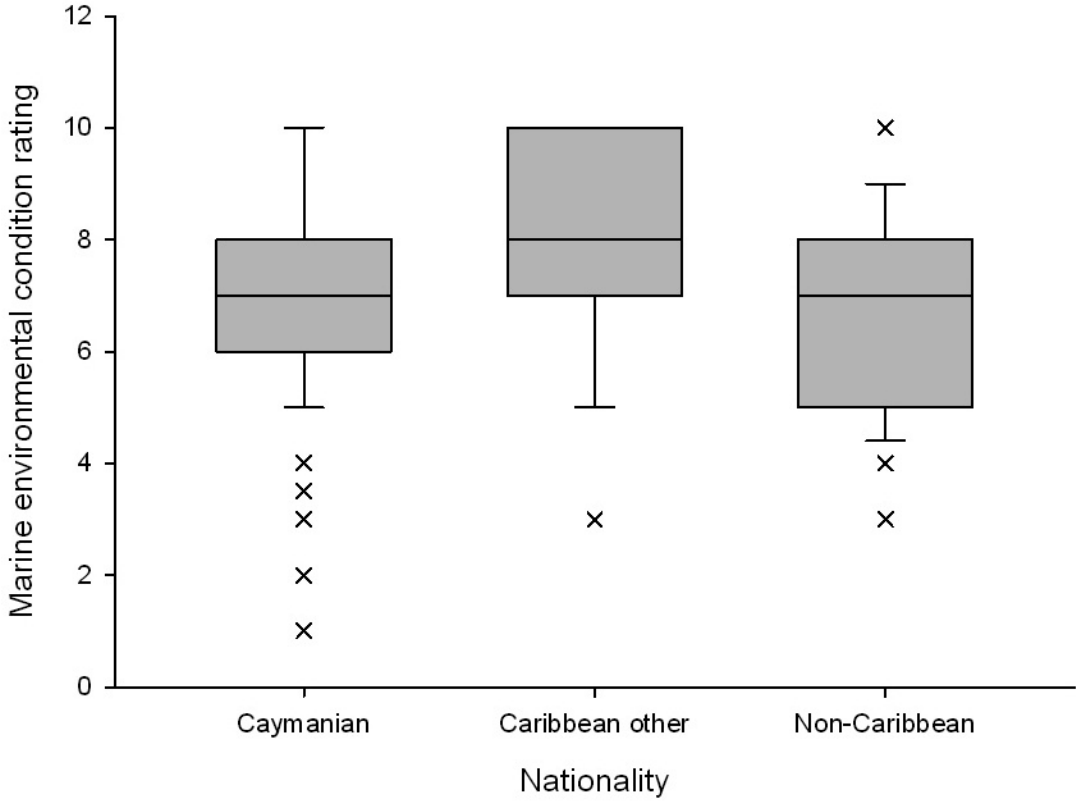
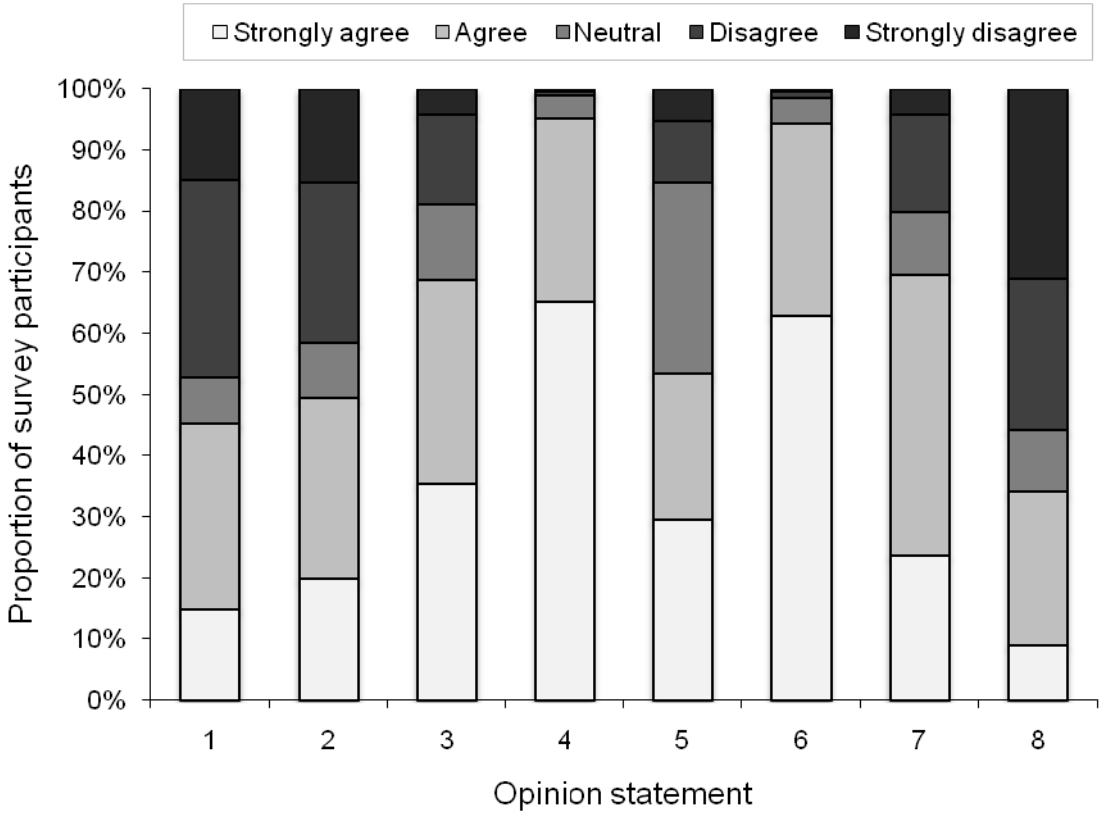


Figure 12. Median survey respondent rating of the condition of the marine environment around Grand Cayman, dependent on nationality (n: Caymanian = 163, Caribbean other = 47, non-Caribbean = 46). Centre horizontal lines show medians, boxes show quartiles, whiskers show ranges and x marks indicate data outliers.

84% of respondents supported the idea of marine environmental management on Grand Cayman, despite opinions on the current effectiveness of management. 6% of participants were against marine management initiatives, while 6% of opinions were neutral and 4% of respondents chose not to express their view (n = 272).

The majority of survey respondents on Grand Cayman agreed that a) conservation of coral reefs was important for the island and that b) the marine environment of the Cayman Islands is valuable and should be conserved (Figure 13). Many individuals agreed with the statement that the marine parks are working well, are in the right locations and are adequately sized (70%), however, 20% of participants disagreed, commenting frequently that management was ineffective and that improvements were required. 56% of participants held the opinion that enforcement of the marine parks is inadequate, nearly half of all survey respondents believed that some species of fish are overfished around Grand Cayman (49%), and 47% believed that the sea is at risk from humans on the island.



Statement	Description
1	The sea is not at risk from humans on the island
2	Some species on the island are overfished
3	Areas closed to all fishing will improve fishing elsewhere around the island
4	Conservation of coral reefs is important for the island
5	Resident fishers pose greater impact on the marine environment than sports fishers
6	The marine environment of the Cayman Islands is valuable & should be conserved
7	The MPAs on the island work well, are in good locations and are adequately sized
8	Enforcement of the marine protected areas around the islands is adequate

Figure 13. Opinions of Grand Cayman survey participants to eight statements relating to the condition of the marine environment and current marine management around the Cayman Islands (n = 267).

Multivariate analysis on the opinions of the fishing community on the environment and management, indicated no clear patterns based on many of the socio-demographics of the surveyed population (Appendix 5). However, a significant difference in the views of respondents dependent on nationality was found (ANOSIM, R = 0.063, *P* = 0.004) (Figure 14). The views of respondents born elsewhere within the Caribbean differed from those of Caymanian fishers (R = 0.058, *P* = 0.027), and those of respondents originating from outside of the Caribbean (R = 0.052, *P* = 0.001). The questions that contributed the most to the overall dissimilarity between views of the three groups were those that related to the respondent's perception of whether any fish species around the island are overfished and whether marine park enforcement was adequate around Grand Cayman (>13% contribution each to overall dissimilarity).

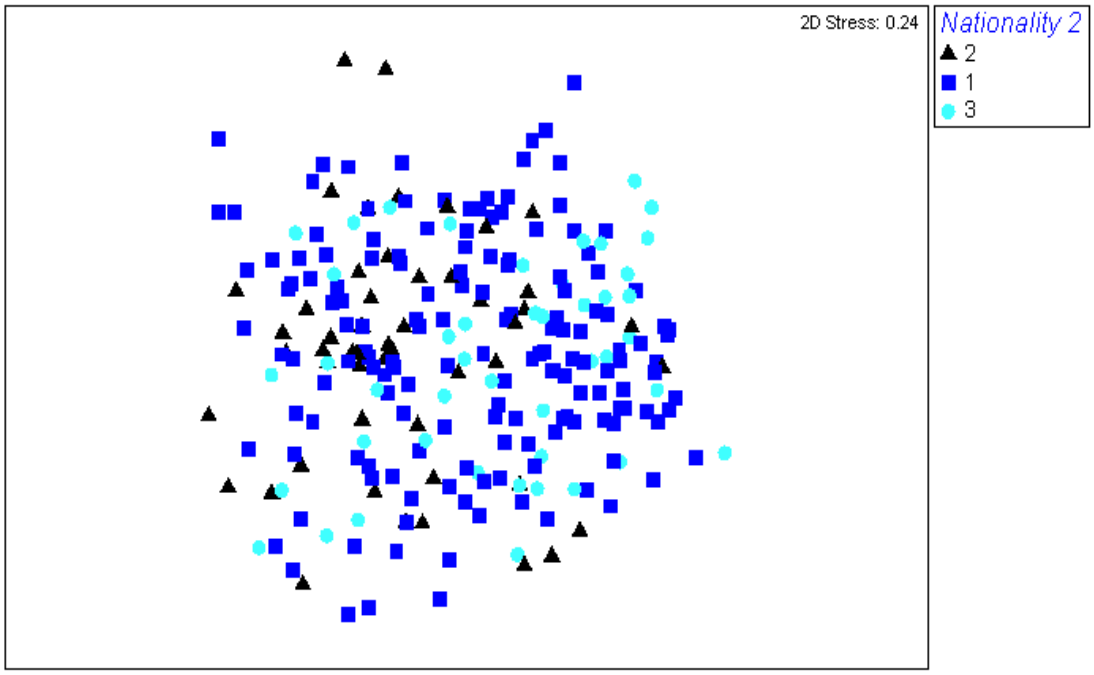


Figure 14. MDS ordination plot representing the 2-dimentional similarities between the views of survey respondents with different nationalities on Grand Cayman (1 = Caymanian, 2 = Caribbean other, 3 = non-Caribbean) (n = 256).

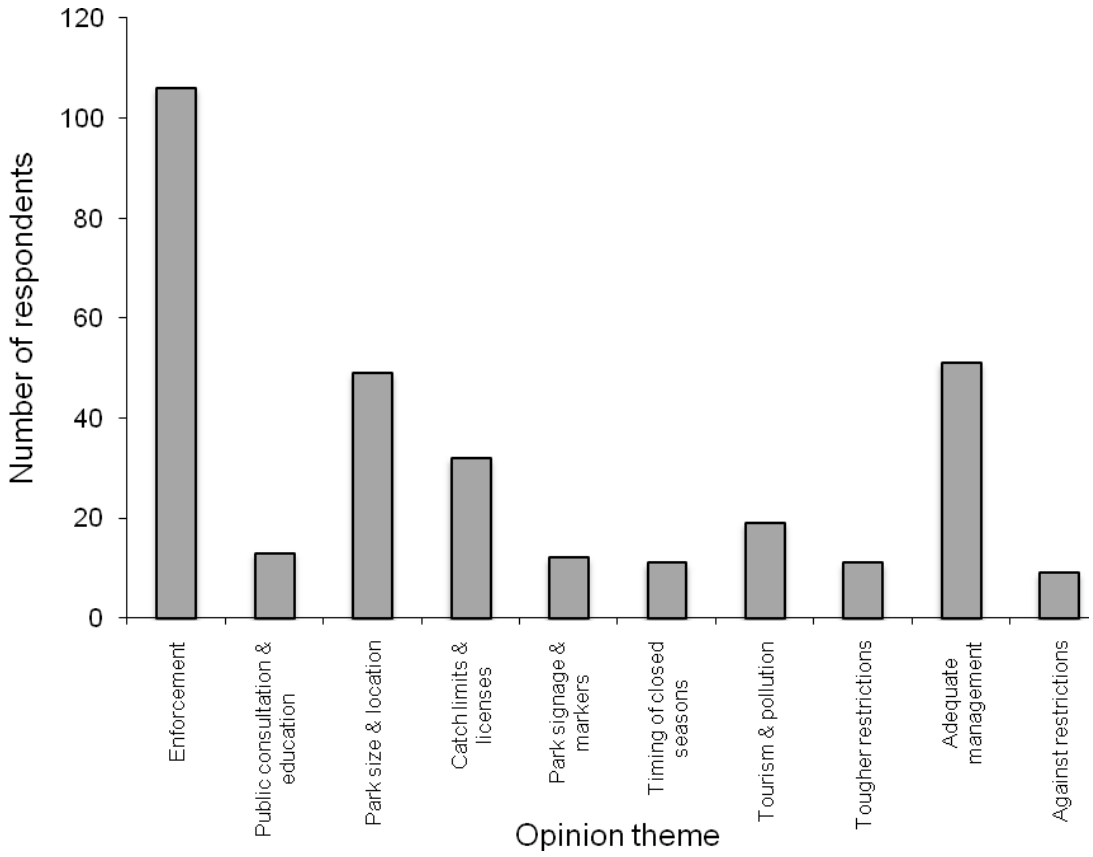


Figure 15. Major opinion themes expressed by survey participants on Grand Cayman when asked an open ended question about their feelings on the current management of the marine environment around the island (n = 234). The number of respondents that covered each opinion theme is show.

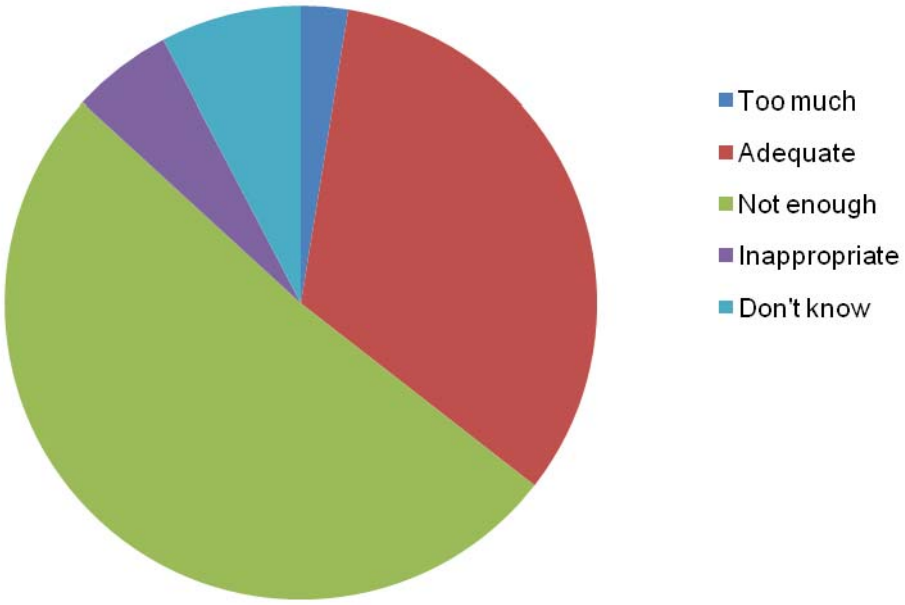


Figure 16. Proportional response of survey participants when asked their opinion on the current adequacy of enforcement around Grand Cayman. Socio-economic questionnaires were undertaken during February and March 2011 (n = 273).

When asked the open-ended question regarding participant's opinions on the current management of the marine environment around Grand Cayman, a number of re-occurring themes appeared in the responses (Figure 15). 106 fishers commented on the state of marine park enforcement, many of which stated that more enforcement efforts were needed (51% of all survey participants, Figure 16), including policing to cover night time hours. A significant number of fishers commented on the location and size of the marine parks (49 respondents), many stating that a park rotation scheme should be introduced on the island and that marine parks should be extended to cover larger areas. Catch limits, size limits and licenses were another topic, which was considered important by a number of survey participants (31 individuals), many of whom felt that the issue of the exploitation of small, undersized fish needed to be addressed by Government, as well as suggesting that a license to fish could be introduced. Additional issues in the marine environment related to the dive industry, boat traffic and pollution were also addressed by a number of fishers who suggested that improved management of these factors was required. See Appendix 6 for a list of commonly occurring opinions of management.

3.1.3 Socio-demographics

The majority of survey participants on Grand Cayman were male (263 individuals: 96%), with only 12 female fishers having participated in the survey (Table 3). 63% of questioned fishers were Caymanian and the remainder were expatriates, with representatives from Jamaica, Honduras, Cuba, Columbia, North America, the UK, Australia, South Africa, the Philippines and Western Europe. 62% of survey participants had been resident in the Cayman

Islands for their entire lives, or since they were small children. 60% of the surveyed fishing community fell between the ages of 35 and 54, and 19% of survey participants were employed in marine related jobs, which included boat captains, fishing charter operators, boat maintenance workers and full-time fishers. Small numbers of respondents fell into the student, retired and unemployment occupational categories (6, 14 and 7, respectively) and the remaining participants were employed in a wide variety of non-marine related jobs, including those in the finance sector, engineering, heavy labour, tourism, government and service sector.

Table 3. Socio-demographic information of fishers on the Cayman Islands who participated in a fishing pressure survey conducted between February and March 2011. The number of survey participants for each demographic (sex, nationality, occupation, age and length of residency) on the respective island is displayed.

Socio-demographic	Grand Cayman	Cayman Brac	Little Cayman
Sex:			
Male/Female	263/12	59/4	14/2
Nationality:			
Caymanian	174	54	11
Expatriate	101	9	5
Occupation:			
Marine related	51	8	3
Non-marine related	197	36	10
Student	6	2	0
Retired	14	12	2
Unemployed	7	3	1
Age:			
<18	4	2	0
18-24	14	3	1
25-34	51	5	3
35-44	98	14	4
45-54	68	14	4
55-64	30	14	0
65-74	8	8	4
75+	2	3	0
Residency:			
<1 year	4	0	2
1-5 years	19	6	3
6-10 years	24	0	3
11-25 years	37	10	3
>25 years	19	3	1
Entire life	171	44	4

3.2 CAYMAN BRAC

3.2.1 Fishing pressure

A total of 63 resident questionnaires were conducted on Cayman Brac between the 6th–11th February 2011, 62 of which were used for further analysis. Questionnaires not incorporated into analysis were conducted with fishers who were either not happy to engage in the survey, or from a source that was not deemed reliable by the analyst. Four of the 62 survey participants did not engage in fishing activities during the month previous to the time of the survey. Survey respondents that had fished reported a total catch of 4424 fish and 10 conch during the month of January 2011 and a mean catch of 78 fish (± SD 88.5) per person per month (n= 58).

3580 reef fish (81% of the total) were reported as caught by Cayman Brac survey respondents during the month prior to the survey period, where as the total pelagic fish species catch was 824 (19% of the total). Snappers were the fish species targeted most frequently, with respondents reporting a total monthly catch of 1387 snappers during January 2011 (Figure 17). Of the reef-associated species caught, triggerfish (*Canthidermis sufflamen* and *Balistes vetula*) were also targeted frequently, as were Barracuda (Figure 17), although many fishers reported releasing the latter after capture. Wahoo and dolphin were the pelagic species caught in higher numbers during January (465 and 292 fish respectively).

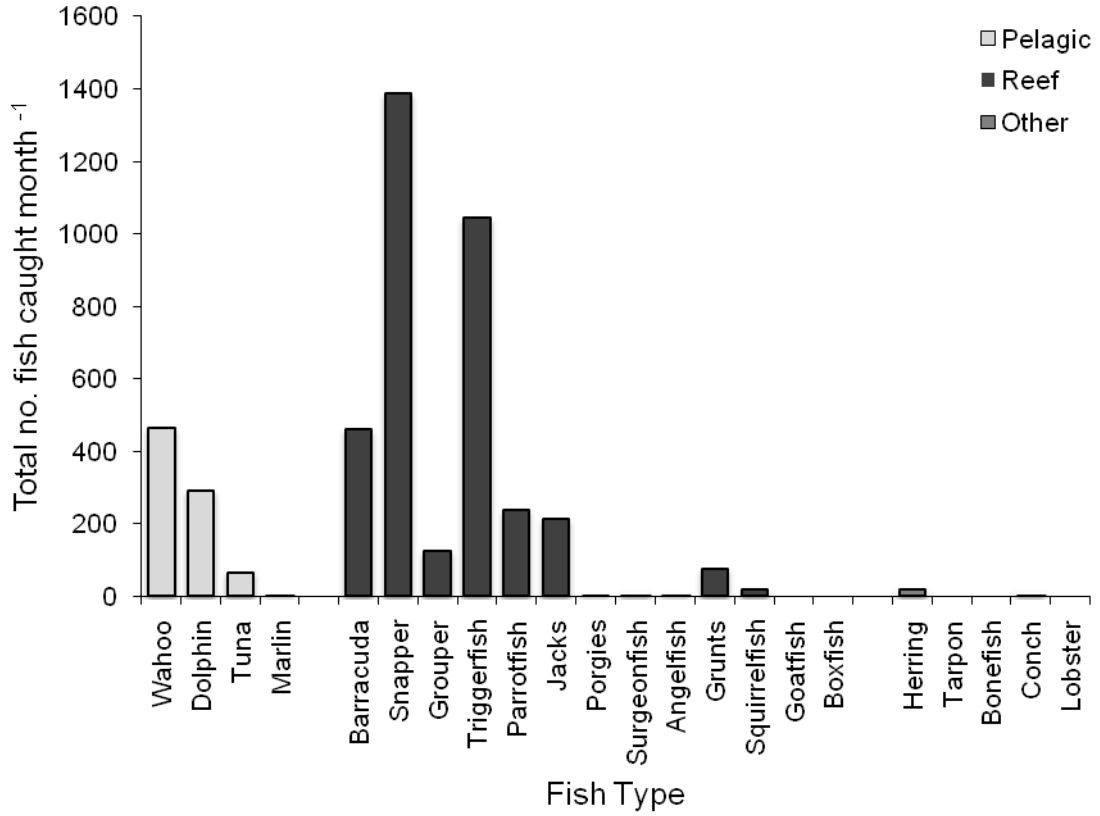


Figure 17. Quantities of fish, conch and lobster caught by Cayman Brac survey respondents during a monthly period (January 2011) around the sister islands (n= 62). Light grey bars = pelagic species, dark grey bars = reef species, mid grey bars = 'other' species.

Three of the Cayman Brac respondents fished only around Little Cayman during January 2011, catching a total of 250 reef fish and 36 pelagic fish in Little Cayman waters. 26 addition fishers visited waters around both islands to fish during a monthly period.

A significant difference in monthly catch size was detected between respondents that targeted different fish types (Kruskal-Wallis test, χ^2 = 7.868, P = 0.020). The median numbers of fish caught by reef fishers, and by respondents fishing for mixed species, were both significantly greater than the total monthly catch size reported by fishers targeting only pelagic species (Mann-Whitney U tests, $P < 0.05$). The median catch size of boat and shore based fishers was not found to differ significantly (Mann-Whitney U test, U = 76.00, $P > 0.05$) (Table 4), and no evidence was found to suggest an effect of nationality on the number of fish caught (Median catch size: Caymanian fishers = 47.0 fish, non-Caymanian fishers = 56.5 fish) (Mann-Whitney U test, U = 177.00, $P > 0.05$). The structure of the fish community caught by survey respondents on Cayman Brac was significantly different for boat, shore and mixed platform fishers (ANOSIM, R = 0.221, P = 0.001). Post-hoc testing revealed the differences to lie between pelagic fishers and the other two categories ($P < 0.05$) (Figure 18), and SIMPER analysis indicated that snapper was the fish group that contributed most to the dissimilarity between the three groups (Appendix 3).

Table 4. The total number of fish caught, number of days spent fishing, and Catch Per Unit Effort (CPUE = number of fish caught per day) of survey participants on Cayman Brac during a monthly period prior to the time that surveys were conducted. Data is present based on the type of fish landed (reef, pelagic and mixed species catches) and the fishing platform (boat, shore and mixed). Mean (± standard error) and median values are shown.

	Fish Type			**Fishing platform**		
	Reef	Pelagic	Mixed	Boat	Shore	Mixed
Total no. fish caught month^{-1}						
Mean	70.6	33.5	94.5	77.3	42.5	95.5
SE	± 15.4	± 23.5	± 18.6	± 13.4	± 23.8	± 31.2
Median	48.4	5.5	63.5	42.0	13.0	80.0
n	20	8	30	39	6	13
Fishing effort (days fishing month^{1})						
Mean	9.4	5.4	9.7	8.9	8.3	9.7
SE	± 1.7	± 1.6	± 1.4	± 1.0	± 3.6	± 2.7
Median	8.0	4.5	7.5	8.0	5.5	6.0
n	20	8	30	39	6	13
CPUE (no. fish day^{-1})						
Mean	12.8	4.2	10.1	10.7	5.4	11.2
SE	± 5.3	± 1.6	± 1.4	± 2.8	± 2.8	± 2.7
Median	5.5	2.7	8.5	6.1	2.4	9.4
n	20	8	30	39	6	13

SE = Standard Error, n = number of replicates

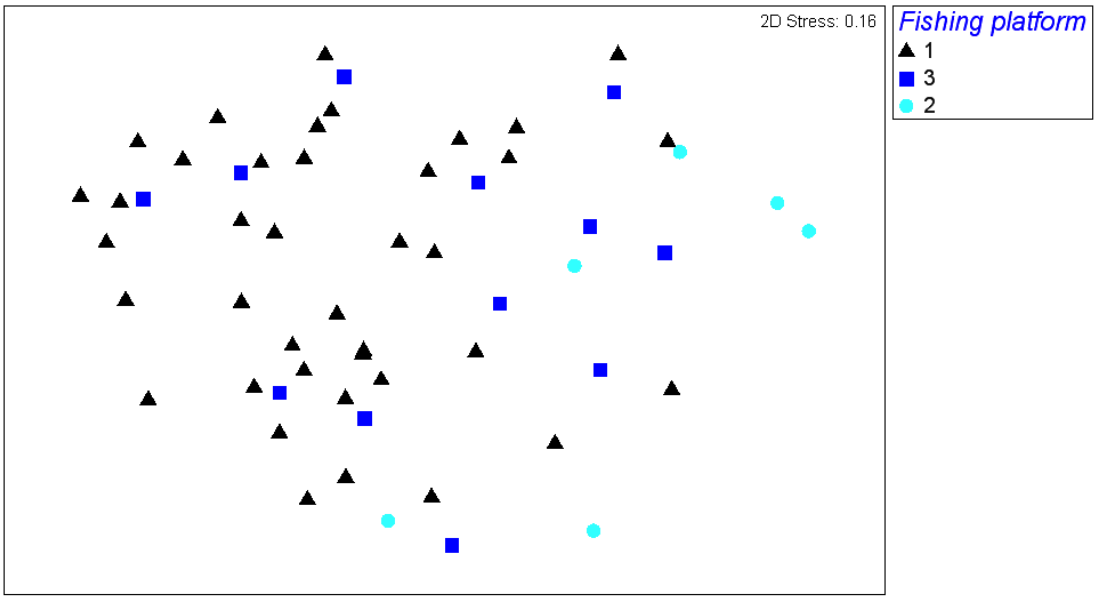


Figure 18. MDS ordination plot representing the 2-dimentional similarities between fish communities caught by respondents fishing from different platforms on Cayman Brac (1 = boat, 2 = shore, 3 = mixed) (n = 58).

On average Cayman Brac fishers kept 86% (± SD 21.4) of their catch, releasing the remainder back into the marine environment. The majority of respondents (63%) reported engaging in fishing activities on a weekly basis (Figure 19), with a mean number of days spent fishing per month of 8.4 (± SD 7.4) (n = 62). The mean number of hours fishers spent with fishing gear deployed in the water was 5.0 (± SD 2.1).

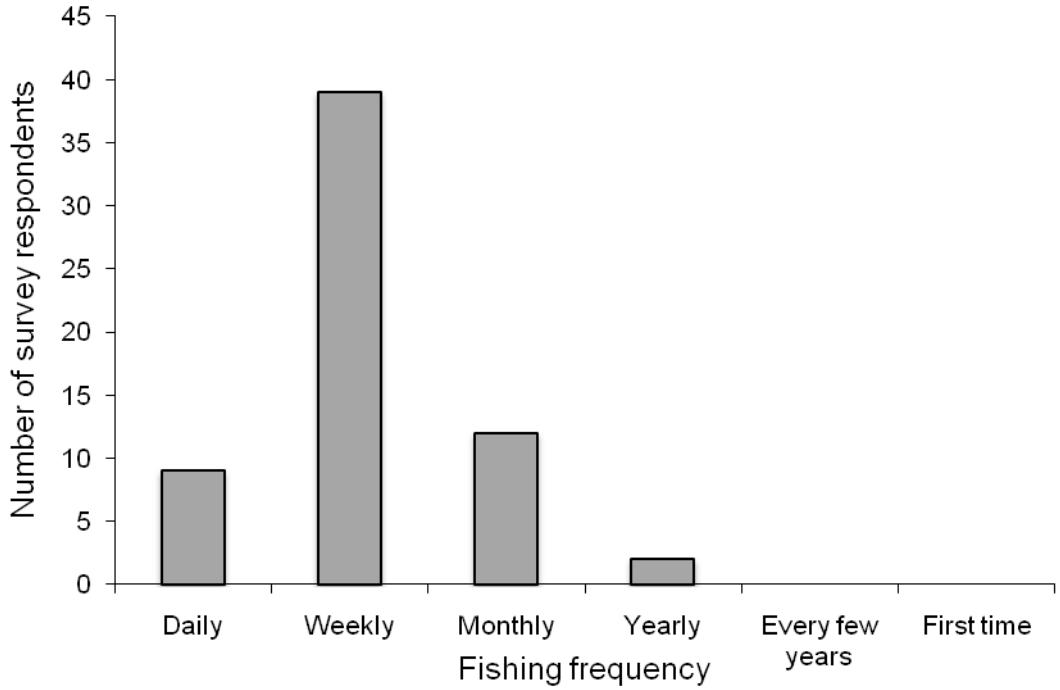


Figure 19. The frequency distribution of Cayman Brac survey respondents, based on the frequency of fishing activity around the Sister Islands (n = 62).

Figure 20. The proportion of Cayman Brac survey respondents represented in different categories based on a) the main reported reason for fishing (n= 62) and b) the time of day 'on average' that respondents fish (n = 62).

The predominant reason for fishing was 'for food', with 57% of respondents stating this as their primary motive. 24% of respondents fished for social

purposes, while 19% engaged in fishing practices to provide a source of income (Figure 20a). The majority of fishers reported fishing during mornings (81%) (Figure 20b). Weekend mornings were the most frequently chosen time of day that respondents fished, representing 55% of the respondents' choices. As on Grand Cayman, results indicated that nationality had an influence on the primary reason that respondents fished (Chi-square test, χ^2 = 10.000, df = 1, P <0.01), with a greater proportion of Caymanian respondents fishing for food or as a source of income (Figure 21).

Use of handlines from boat platforms was the most frequent fishing method reported by respondents on Cayman Brac (52% of respondents) (Figure 22). Only one respondent reported spear gun fishing as one of many methods used, however, none of the respondents reported using spear guns solely as a method to catch fish around the island (Table 5).

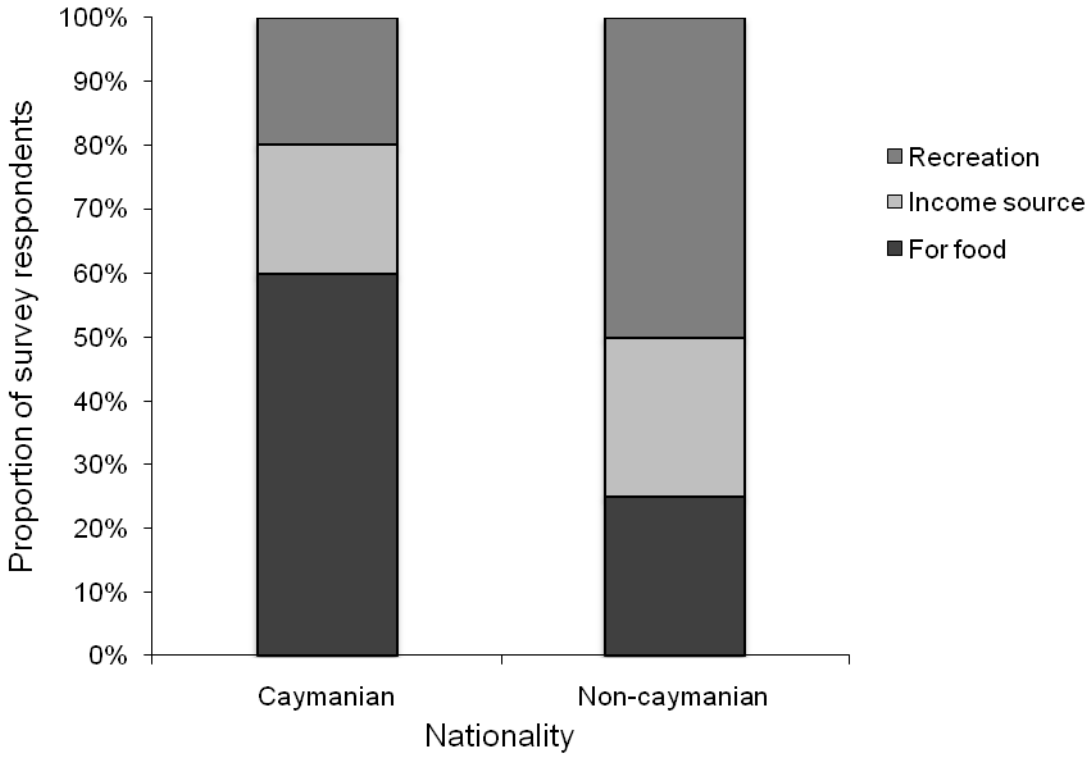


Figure 21. The proportion of total survey respondents represented in each category for the primary reason that fishers engaged in fishing activities on Cayman Brac (n = 58).

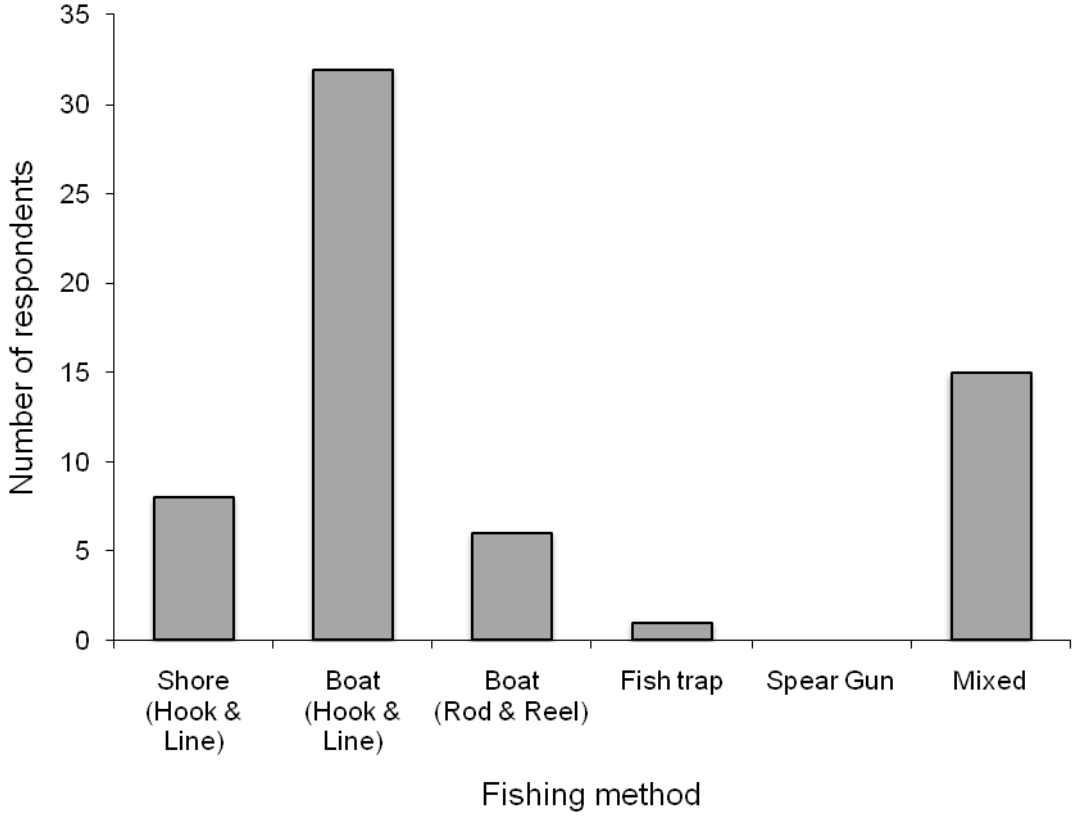


Figure 22. The frequency of Cayman Brac survey respondents using different fishing methods on the Sister Islands, as reported during fishing surveys in February 2011 (n = 62).

The total mean Catch Per Unit Effort (CPUE) (number of fish caught per day) on Cayman Brac was 10.2 fish day^{-1} (± SD 15.1) (n = 58). A significant difference was found in CPUE of fishers targeting different fish types (Kruskal-Wallis test, χ^2 = 6.791, df = 2, *P* = 0.034). Median CPUE of fishers targeting a mix of species was significantly higher than for those catching pelagic fish (Mann-Whitney U test, *U* = 49.0, *P* = 0.01), although no difference was found in CPUE between reef and pelagic fishers (Mann-Whitney U test, *U* = 42.5, *P* = 0.055) (Table 4). Boat and shore fishers showed no difference in CPUE either (Mann-Whitney U test, *U* = 66.5, *P* > 0.05).

When data were divided further into the different types of fishing techniques used by fishers on Cayman Brac, fishing effort (in terms of days spent fishing per month) was fairly evenly distributed between categories (Figure 23). CPUE was highest for survey participants fishing from boat for reef fish, but was fairly similar for all other fishing categories (Figure 23).

Table 5. Definitions of different fishing techniques reported by fishers during fisheries surveys on Cayman Brac, and the number of fishers represented in each category (n = 58).

Fishing method	Abbreviation	Respondent no.
Fishing from boat for reef fish species	Boat/Reef	8
Fishing from boat for pelagic species	Boat/Pelagic	8
Fishing from boat for reef & pelagic species	Boat/Mixed	23
Fishing from shore for reef fish species	Shore/Reef	6
Fishing with spear gun for reef fish species	Spear gun	0
Fishing with mixed methods for reef species	Mixed/Reef	5
Fishing with mixed methods for mixed species	Mixed/Mixed	8

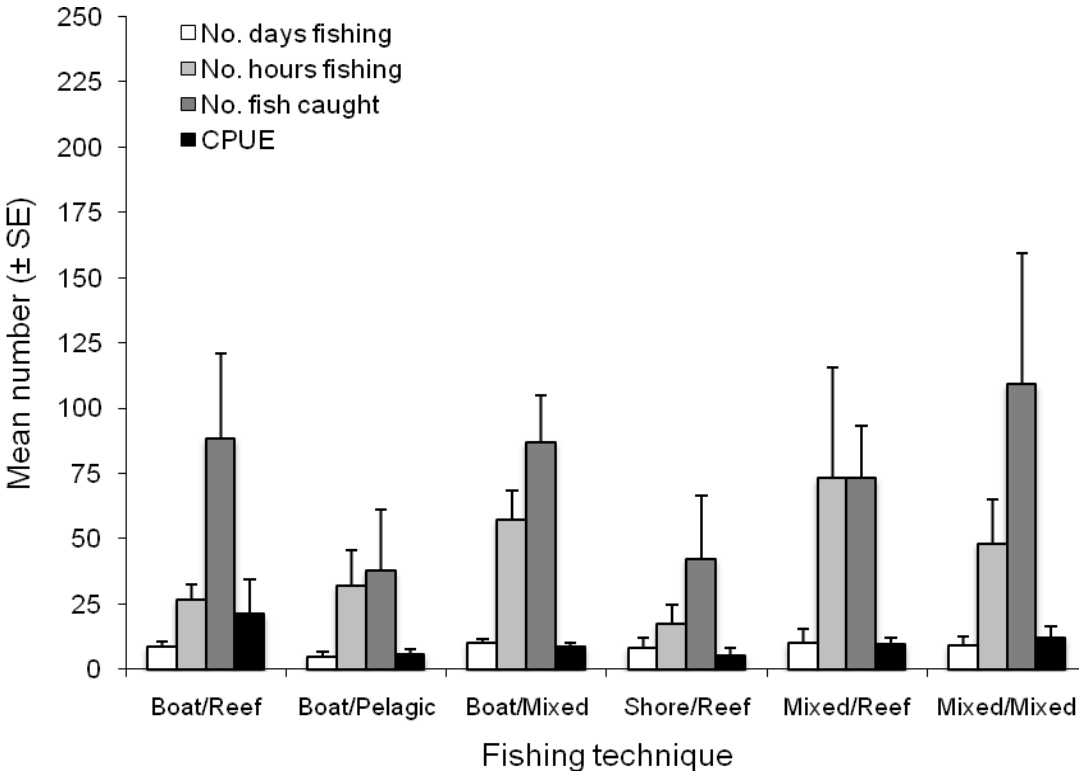


Figure 23. Fishing effort of survey respondents interviewed on Cayman Brac during February 2011, based on the fishing technique employed by fishers. The mean number of days and hours spent fishing per month, the mean number of fish caught per month and CPUE (the number of fish caught per day) for January 2011 are shown. SE = Standard error (n = 58).

On Cayman Brac, fishing effort, in terms of the number of individuals visiting each map square, was not uniformly distributed (Chi-square test, χ^2 = 214.23, df = 19, *P* <0.01). The area experiencing greatest fishing effort was distributed around the eastern end of the island from Spot Bay to Pollard Bay (Figure 24). The majority of fishers indicated that they followed shelf drop-off contours distributed around the island, which are locally regarded as areas of high fish abundance, where fishing is often successful. Many fishers also commented on the pelagic fish concentrations (notably wahoo and dolphin) that gather off the eastern and western tips of the island, explaining in part the observed spatial distribution of fishing pressure. The waters experiencing higher levels of fishing effort around Cayman Brac were also those in closer proximity to major boat launch areas around the island. The majority of respondents who visited the three map squares off the western side of the island, in which greatest fishing effort occurred during January 2011, fished from boat platforms (Map square: CB9 = 65%, CB10 = 72%, CB15 = 82%). As expected, the spatial distribution of fishing effort (in terms of the proportion of total respondent fishing trips around the island in each map square) varied between those respondents targeting reef fish and those fishing for pelagic species (Chi-square test, χ^2 = 77.766, df = 9, *P* = <0.01) (Appendix 4).

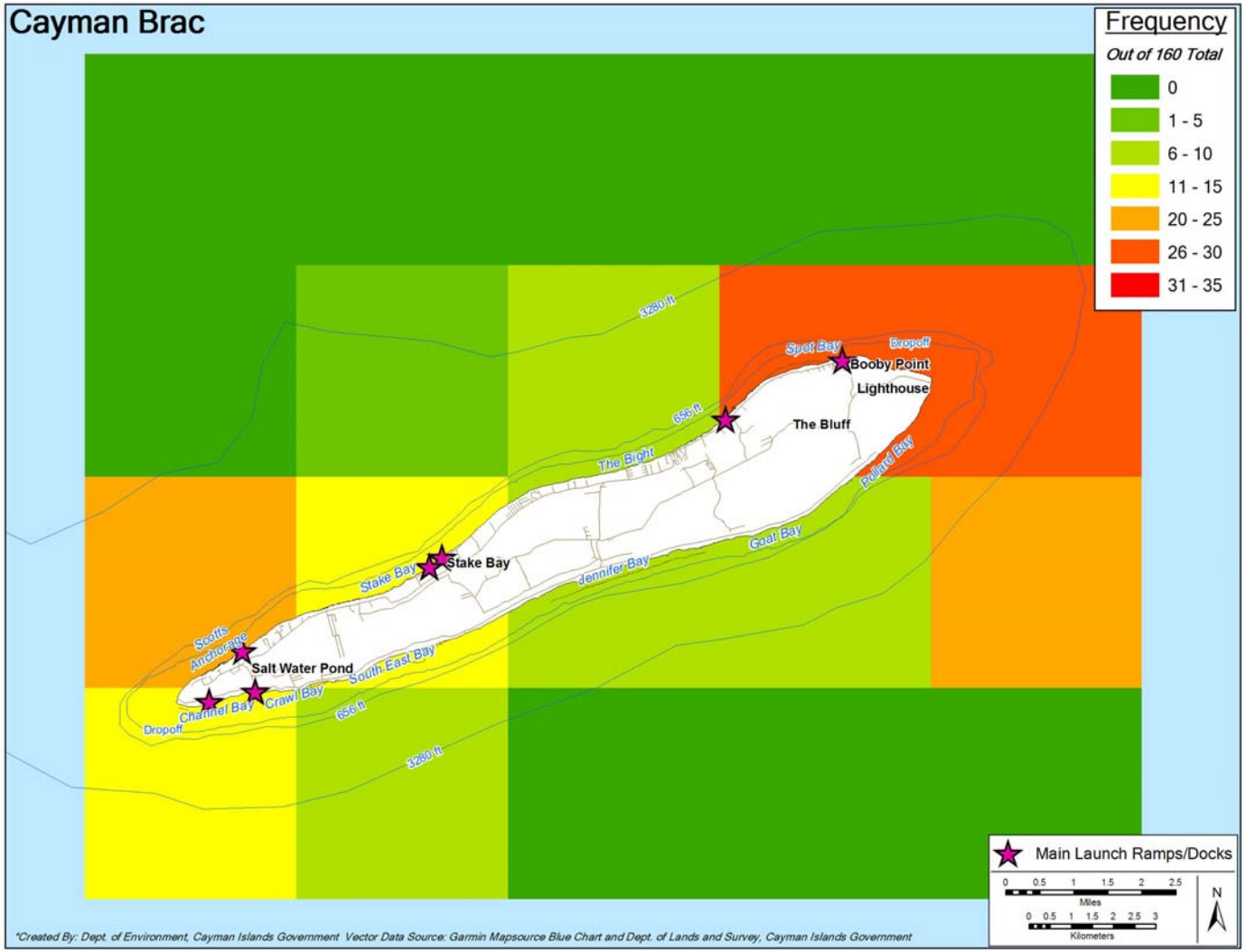


Figure 24. Spatial distribution of fishing effort over a monthly period (January 2011) on Cayman Brac, based on information provided by local residents, ex-patriots and tourists during socio-economic questionnaires performed on the island in February 2011 (n = 60). Star symbols show the locations of major boat launch areas.

3.2.2 Views and Opinions

The majority of survey participants held the opinion that neither the quantity nor the size of fish in populations around Cayman Brac had changed over time (54% and 71%, respectively). However, a number of respondents did state that fish quantity has decreased (either slightly or greatly) over time (38%) (Figure 25).

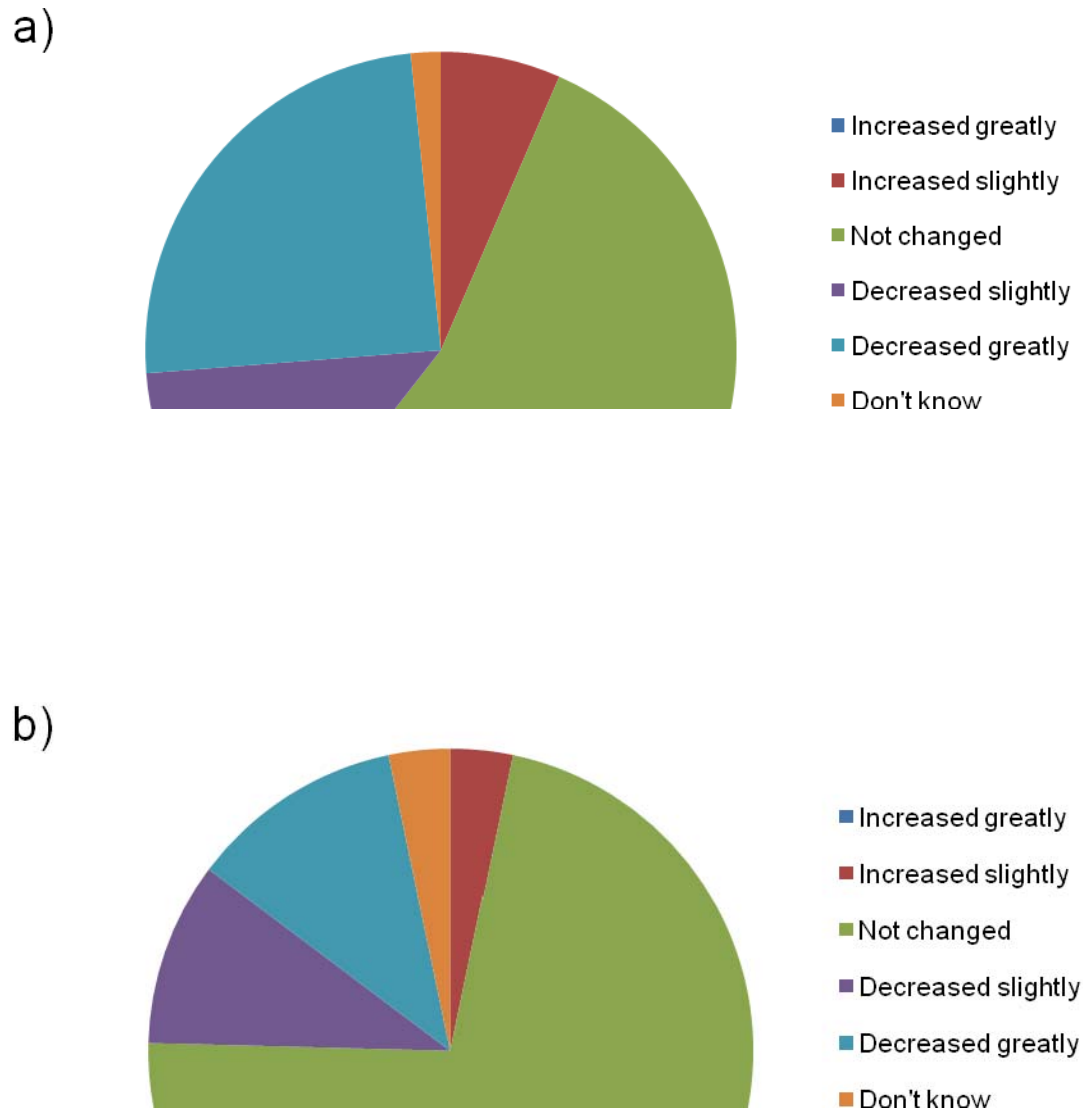


Figure 25. The opinions of Cayman Brac survey respondents on whether a) the average quantity of fish and b) the average size of fish in catches had changed over time. Surveys were conducted on Cayman Brac during February 2011 (n = 61).

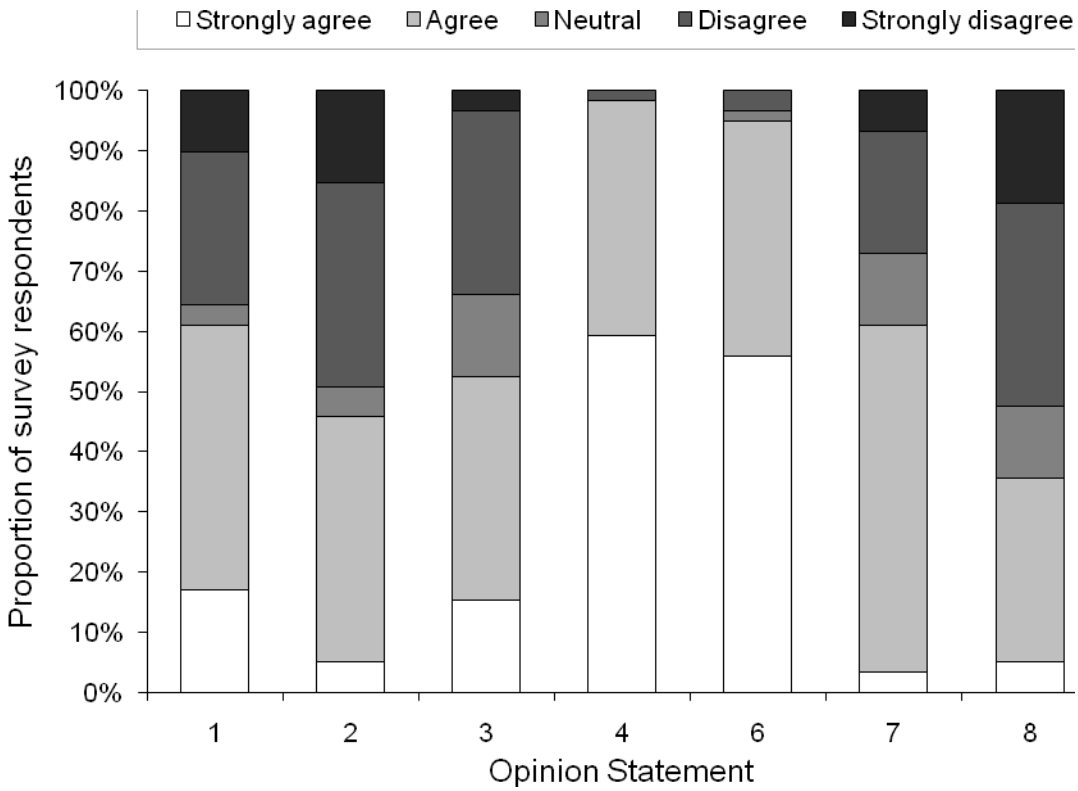
Weather and oceanographic features (tidal state, currents and lunar phase) were the main factors influencing the location in which survey respondents from Cayman Brac chose to fish (64% of the respondents' first choice) (Figure 26). Only one of the survey respondents reported managed zones as the main influencing factor.

Figure 26. Proportional survey responses of Cayman Brac fishers, dependent on the main factor influencing the choice of location in which to fish (n = 61).

The mean response of survey participants, when asked to rate the condition of the marine environment around Cayman Brac on a scale of 1-10 was 7.9 (± SD 1.8), and 79% of targeted individuals rated the condition above 6 on the scale. Nationality did not have an affect on respondent ratings on Cayman Brac (Mann-Whitney *U* test, $U = 180.00$, $P > 0.05$).

67% of respondents supported the idea of marine environmental management on Cayman Brac, despite opinions on the current effectiveness of management. 26% of participants were against marine management initiatives, 5% of opinions were neutral and 2% of respondents stated that they did not have an opinion.

The multiple choice question related to the participant's opinion on whether the impact of fishing was greater for local or sport fishing activities was abandoned during the Cayman Brac survey, after the majority of respondents stated that sports fishing seldom occurs in the coastal waters of the island.



Statement	Description
1	The sea is not at risk from humans on the island
2	Some species on the island are overfished
3	Areas closed to all fishing will improve fishing elsewhere around the island
4	Conservation of coral reefs is important for the island
5	Resident fishers pose greater impact on the marine environment than sports fishers
6	The marine environment of the Cayman Islands is valuable & should be conserved
7	The MPAs on the island work well, are in good locations and are adequately sized
8	Enforcement of the marine protected areas around the islands is adequate

Figure 27. Opinions of Cayman Brac survey participants to eight statements relating to the condition of the marine environment and current marine management around the Cayman Islands (n = 59).

As was the case on Grand Cayman, nearly all survey respondents on Cayman Brac agreed that a) conservation of coral reefs was important for the island and b) the marine environment of the Cayman Islands is valuable and should be conserved (Figure 27). 53% of participants held the opinion that enforcement of the marine parks and restrictions was inadequate and this was a reoccurring comment during the open-ended question about respondent's views on current management strategies. 61% of individuals agreed with the statement that the marine parks are working well, are in the right locations and are adequately sized, however, 27% of participants disagreed. Nearly half of all survey respondents held the opinion that some species of fish are overfished (46%), while the majority of fishers (61%) did not believe that the sea is at risk on Cayman Brac from humans.

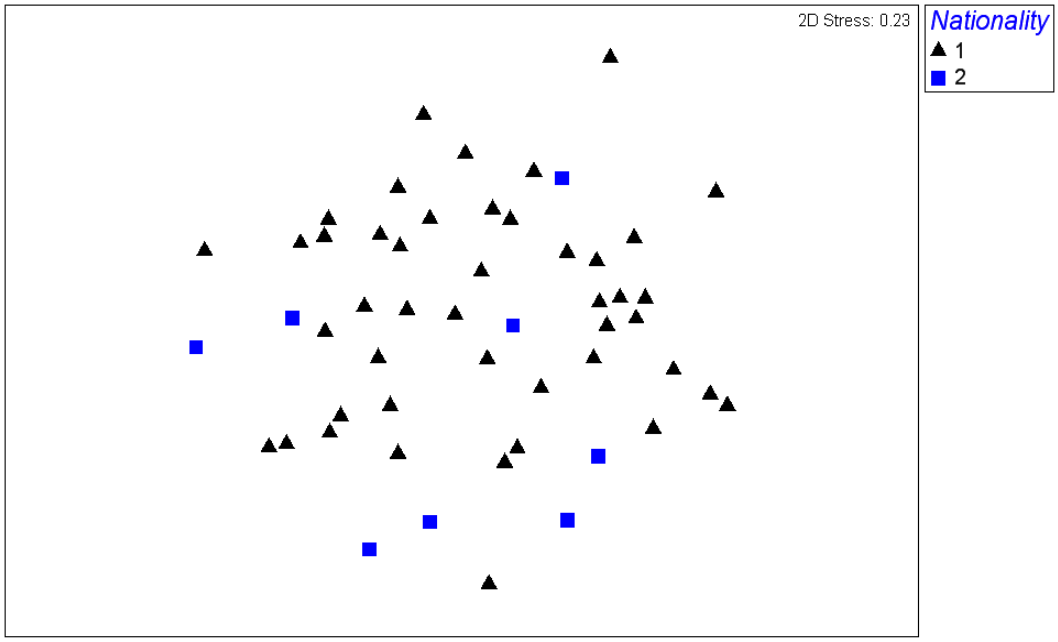


Figure 28. MDS ordination plot representing the 2-dimentional similarities between the opinions of survey respondents with different nationalities (1 = Caymanian, 2 = non-Caymanian) (n = 58).

Multivariate analysis on the opinions of the fishing community on the marine environment and management indicated a significant difference in views of respondents based on nationality (Caymanian versus non-Caymanian respondents) (ANOSIM, R = 0.160, *P* = 0.023) (Figure 28). The question that contributed the most to the overall dissimilarity between views of Caymanian and non-Caymanian fishers was that related to whether the sea is at risk from humans around Cayman Brac (16.07% contribution). A summary of re-occurring opinions that were expressed during the open-ended survey question about current management can be found in Appendix 6.

3.2.3 Socio-demographics

59 of the 63 survey respondents on Cayman Brac were male (89%), 54 of the participants (86%) were Caymanian (91% of which were born and raised on Cayman Brac), and 70% of survey respondents had been resident on the Cayman Islands for their entire lives (Table 3). Expatriate participants (14% of survey respondents) included nationals from Jamaica, Honduras, Canada, the United States and South Africa. Eight individuals were interviewed during the survey on Cayman Brac whose occupation was directly linked to fishing activities, and the majority of participants worked in the service industry. 67% (42 participants) of the surveyed population was between the ages of 35 and 64 years old, with a notable proportion of the population having retired (20%), and only 16% were below 35 years of age.

3.3 LITTLE CAYMAN

3.3.1 Fishing Pressure

A total of 16 fully completed resident questionnaires were conducted on Little Cayman between the 24th–28th February 2011. Survey respondents reported a total catch of 781 fish and 10 lobster during a monthly period, and a mean catch of 56 fish (± SD 36.8) per person per month.

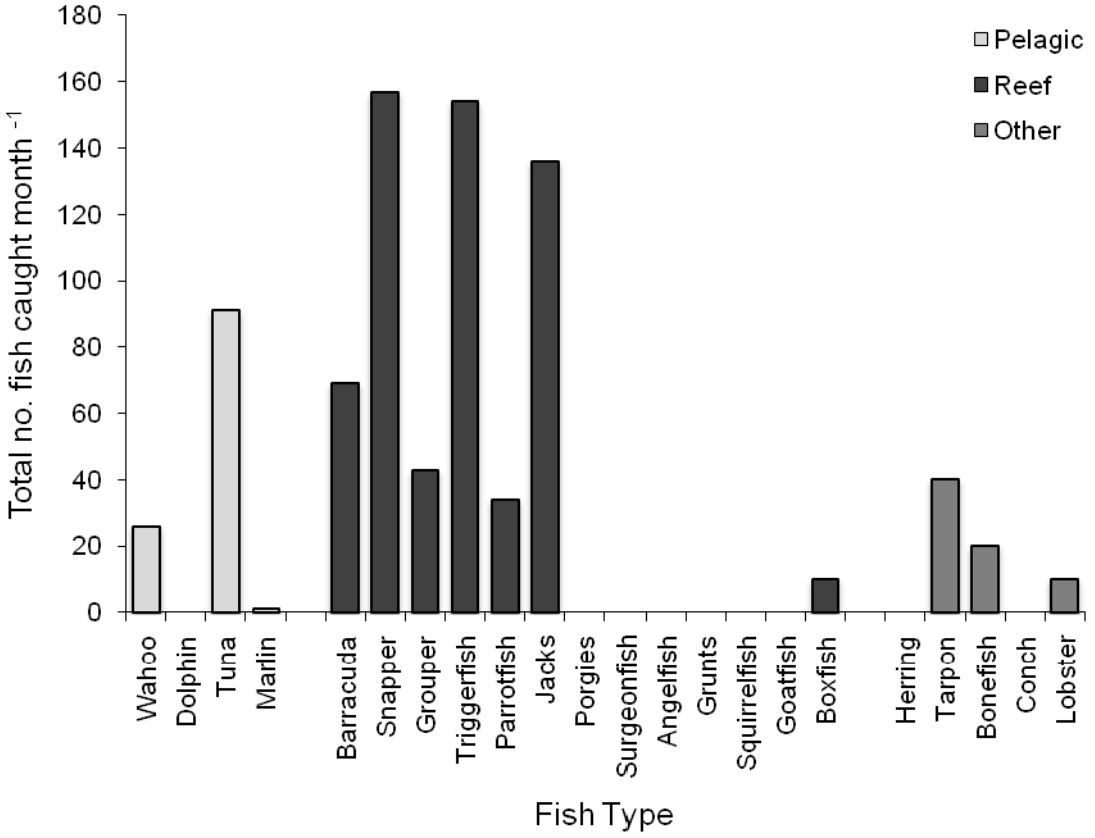


Figure 29. Quantities of fish, conch and lobster caught by Little Cayman survey respondents, during a monthly period (January 2011) around the island (n= 16). Light grey bars = pelagic species, dark grey bars = reef species, mid grey bars = 'other' species.

Snappers, triggerfish and jacks were the reef-associated fish species targeted most frequently by fishers on the island, with respondents reporting a total monthly catch of 157, 154 and 136 fish, respectively, during January 2011 (Figure 29). Pelagic fish species were targeted by Little Cayman fishers less frequently, with yellowfin tuna (*Thunnus albacares*) having been caught in highest numbers in this group over a monthly period (91 fish). 603 reef fish were reported as caught during the month prior to the survey period, where as the total pelagic fish species catch was 118. A total of 60 fish classed as other (bonefish and tarpon) were caught during the monthly period.

On average fishermen kept 88% (± SD 13.0) of the catch, releasing 12% back into the environment (± SD 13.0), and the frequency with which respondents fished on Little Cayman varied from daily to monthly (Figure 30). The mean number of days that Little Cayman respondents spent fishing per month around the island was 7.6 (± SD 9.5), and the mean number of hours fishers spent with fishing gear deployed in the water was 4.7 (± SD 1.6).

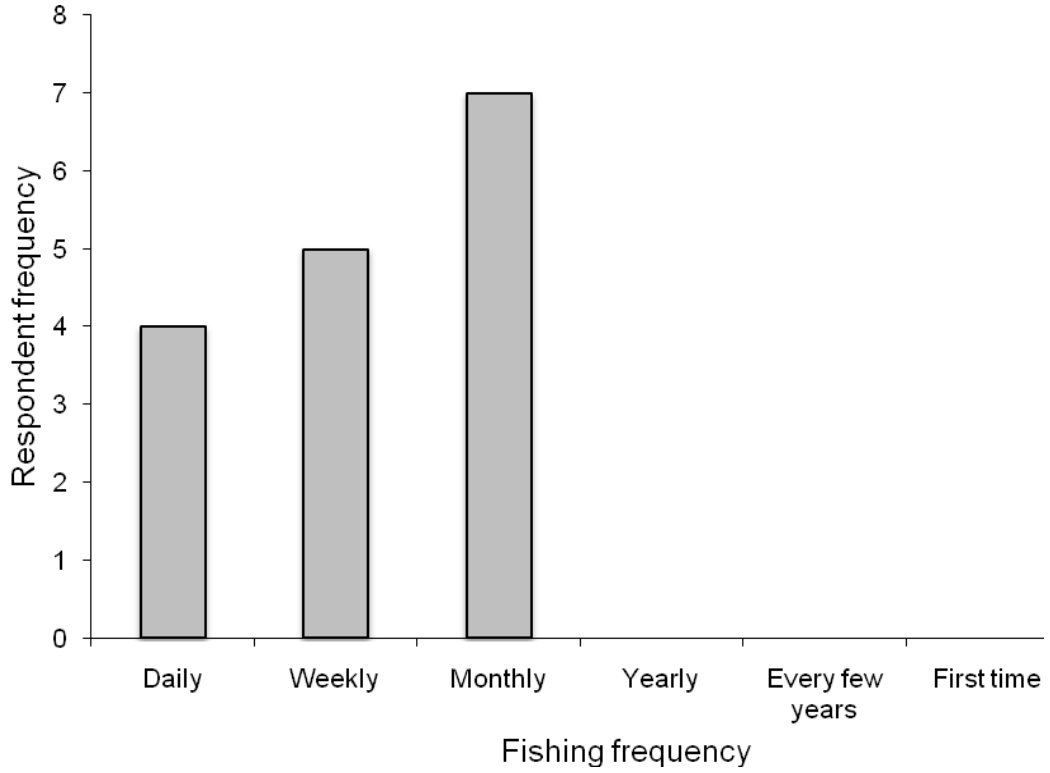


Figure 30. The distribution of Little Cayman survey respondents, based on frequency of occurrence of fishing activities around the island (n = 16).

The predominant reason for fishing was 'for food', with 75% of respondents stating this as their primary motive (n = 16). 12.5% of respondents fished for social purposes, while 12.5% engaged in fishing practices to provide a source of income (Figure 31a). Weekday mornings (31%) and weekend mornings (25%) were both reported to be popular times to fish (Figure 31b). A proportion of survey respondents also reported highly variable fishing habits in terms of the time of day on average that they engaged in fishing practices (31%).

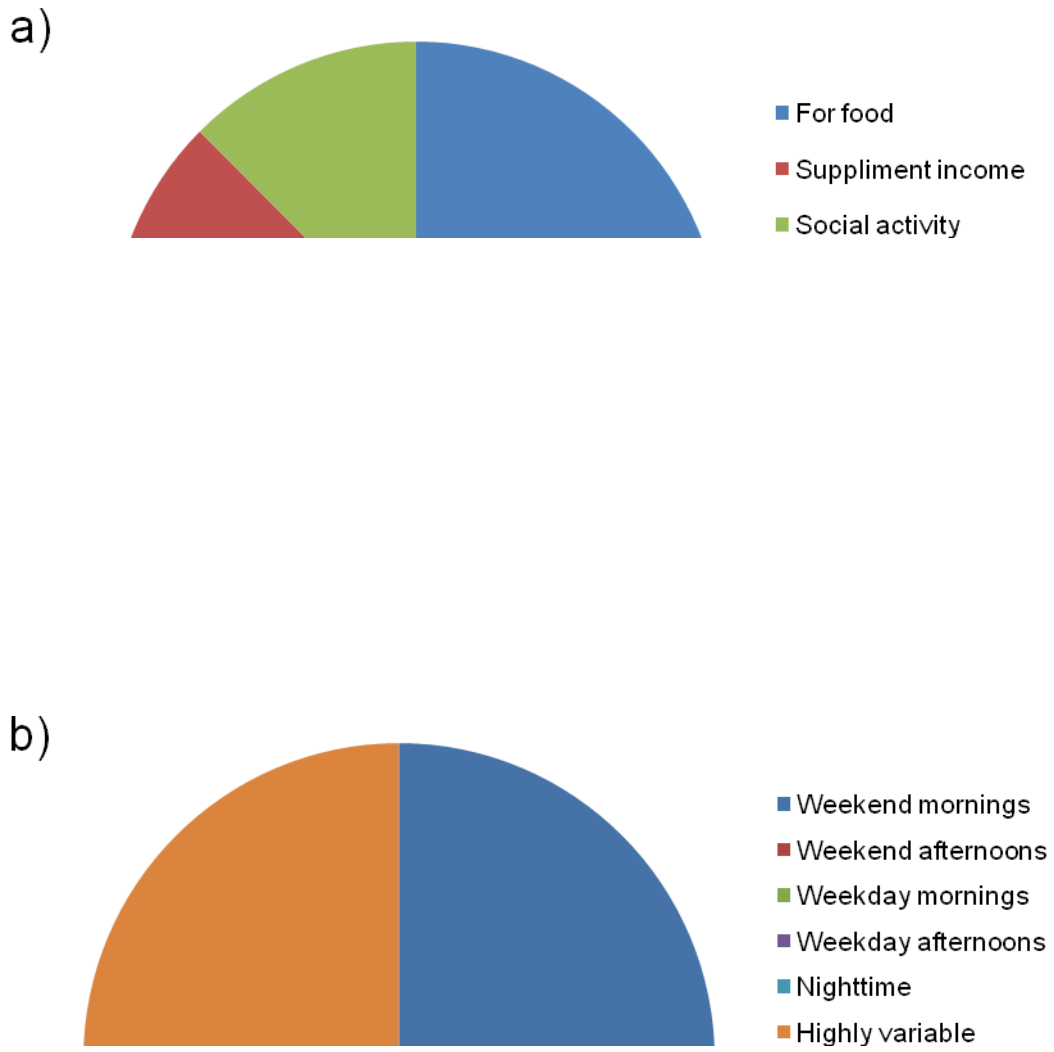


Figure 31. The proportion of Little Cayman survey respondents represented in different categories based on a) the main reported reason for fishing (n= 16) and b) the time of day 'on average' respondents go fishing (n = 16).

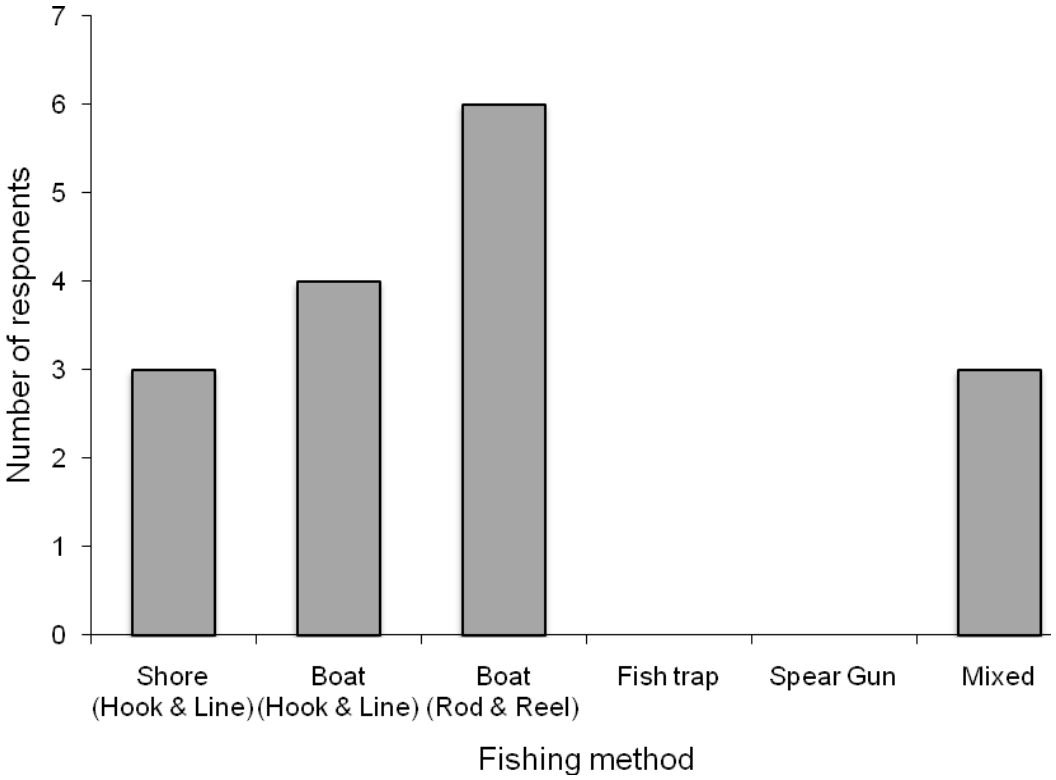


Figure 32. The frequency of survey respondents using different fishing methods on Little Cayman, as reported during fishing surveys on the island in February 2011 (n = 16).

Fishing from boat platforms was the predominant technique reported on Little Cayman, with 58% of respondents engaging in either rod & reel or hook & line techniques from boats (Figure 32). None of the residents interviewed on Little Cayman reported using fish traps or spear guns during their fishing activities. Fishing from boat for reef fish species was the most frequently reported fishing method of choice on Little Cayman (43% of respondents) (Table 6).

Table 6. Definitions of different fishing techniques reported by fishers during fisheries surveys on Little Cayman, and the number of fishers represented in each category (n = 14).

Fishing method	Abbreviation	Respondent no.
Fishing from boat for reef fish species	Boat/Reef	6
Fishing from boat for pelagic species	Boat/Pelagic	1
Fishing from boat for reef & pelagic species	Boat/Mixed	1
Fishing from shore for reef fish species	Shore/Reef	3
Fishing with spear gun for reef fish species	Spear gun/Reef	0
Fishing from boat and shore for reef species	Mixed/Reef	2
Fishing from boat and shore for mixed species	Mixed/Mixed	1

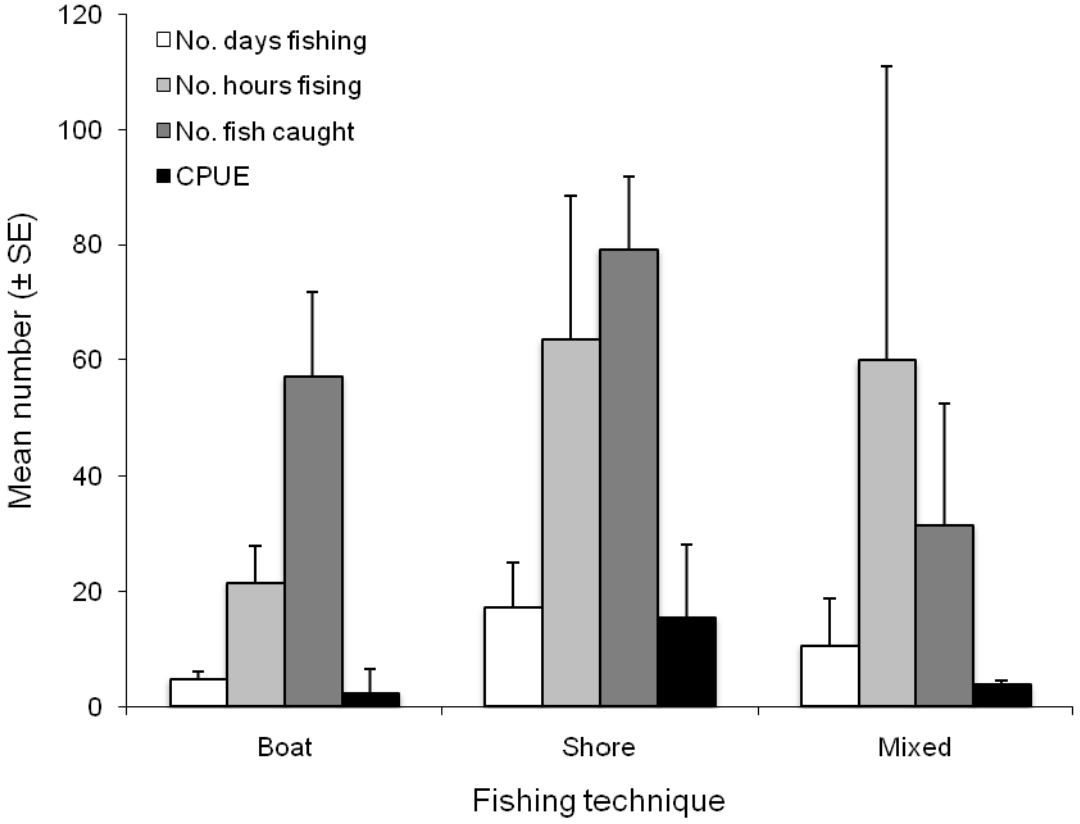


Figure 33. Fishing effort of survey respondents interviewed on Little Cayman during February 2011, based on the fishing technique employed by fishers. The mean number of days and hours spent fishing per month, the mean number of fish caught and CPUE (the number of fish caught per day) for January 2011 are shown. SE = Standard error (n = 14).

The mean total CPUE of fish by respondents on Little Cayman for January 2011 was 11.5 fish day^{-1} (± SD 12.5). The mean reported CPUE was 14.1 fish day^{-1} (± SD 13.9) for reef fish and 6.5 fish day^{-1} (± SD 3.4) for mixed species catches. Mean fishing effort was highest from shore, as was the mean number of fish caught per respondent and CPUE (Figure 33). Statistical analysis was not possible for the survey data from Little Cayman due to low levels of replication (Table 6).

As was the case with the two larger islands, the spatial distribution of fishing pressure on Little Cayman was relatively constrained, and was not uniformly distributed around the island (Chi-square test, χ^2 = 273.43, df = 23, P <0.01) (Figure 34). Survey responses indicated that the western and eastern ends of Little Cayman were the most heavily used during January 2011. The waters off the eastern end of the island, and the area off the western tip of Little Cayman, where heavier fishing took place, were both areas coinciding with the two designated grouper spawning areas around the island. The waters off the southeastern side of the island towards Cayman Brac were also visited frequently. The major factors that survey respondents reported as those influencing fishing location were 'knowledge of fish abundance in an area' (many of which stated came from prior experience) and localized weather and oceanographic features (56% and 44%, respectively).

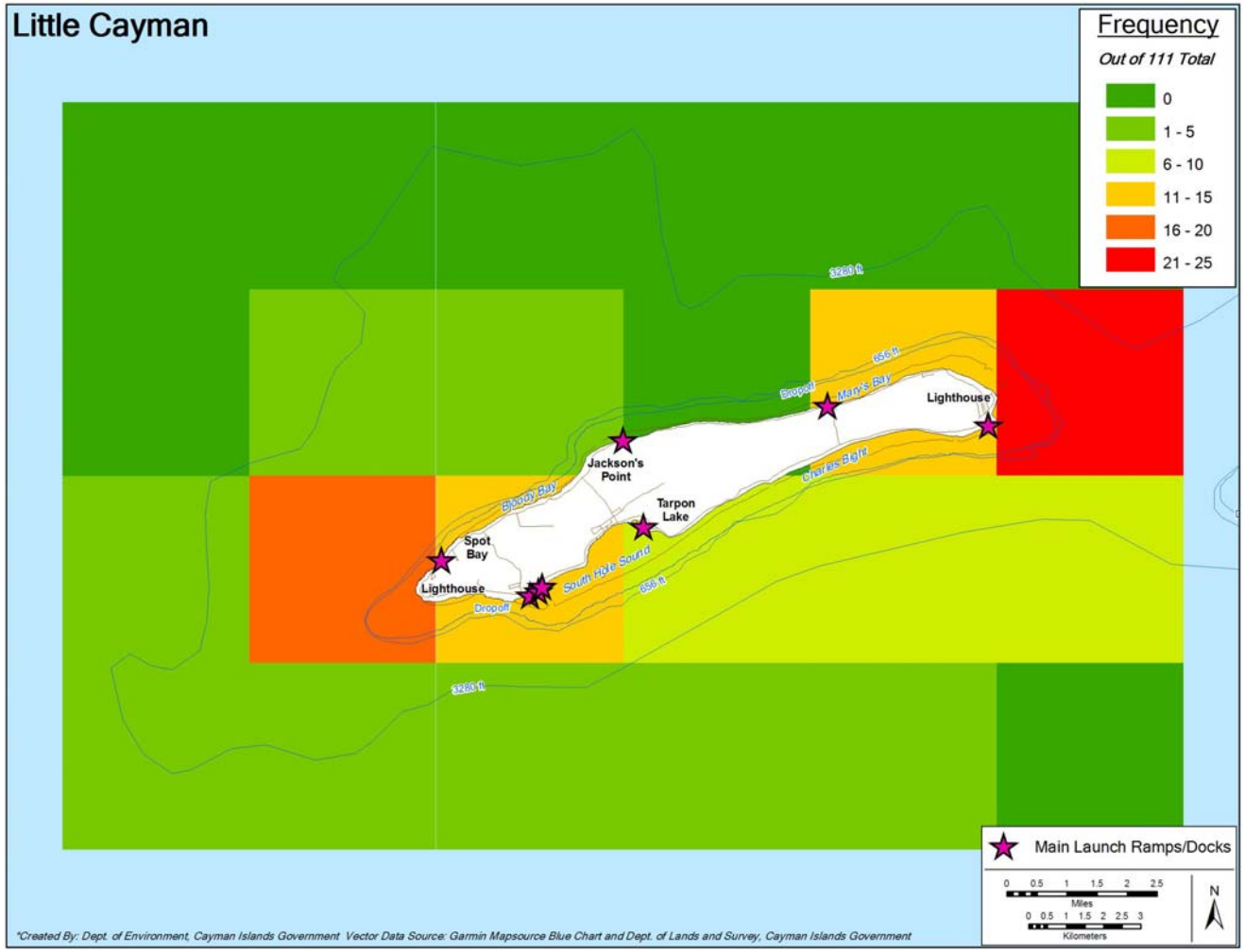


Figure 34. Spatial distribution of fishing effort over a monthly period (January 2011) on Little Cayman, based on information provided by residents, ex-patriots and tourists during socio-economic questionnaires performed on the sister islands in February 2011 (n =16). Star symbols show the locations of major boat launch areas.

3.3.2 Views and Opinions

On Little Cayman, while 44% of respondents believed that the abundance of fish had remained steady over time, 50% of individuals held the opinion that fish stocks had declined either slightly or greatly. In comparison, the majority of participants (75%) believed that the size of fish in populations around the island had not changed over time. (Figure 35).

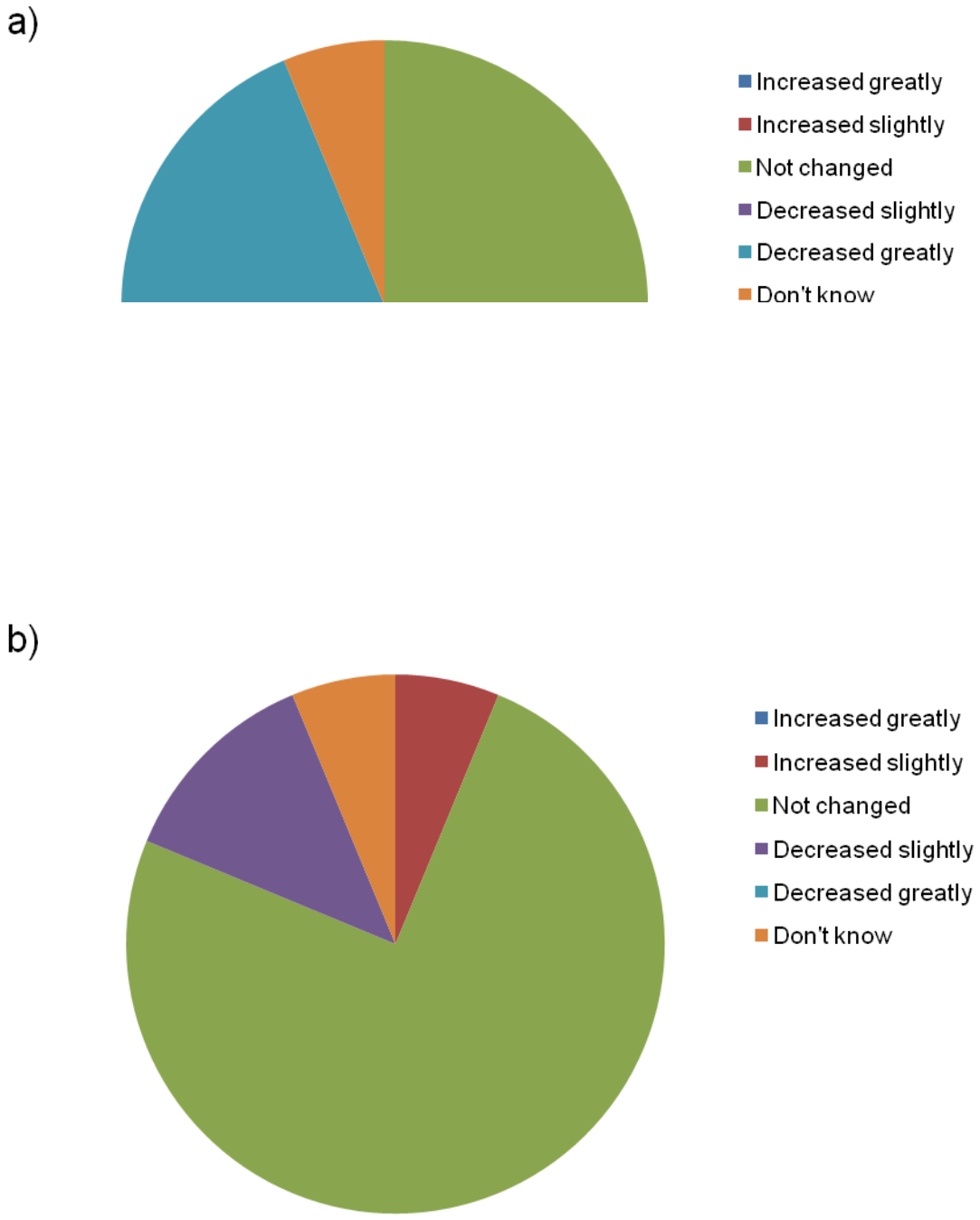
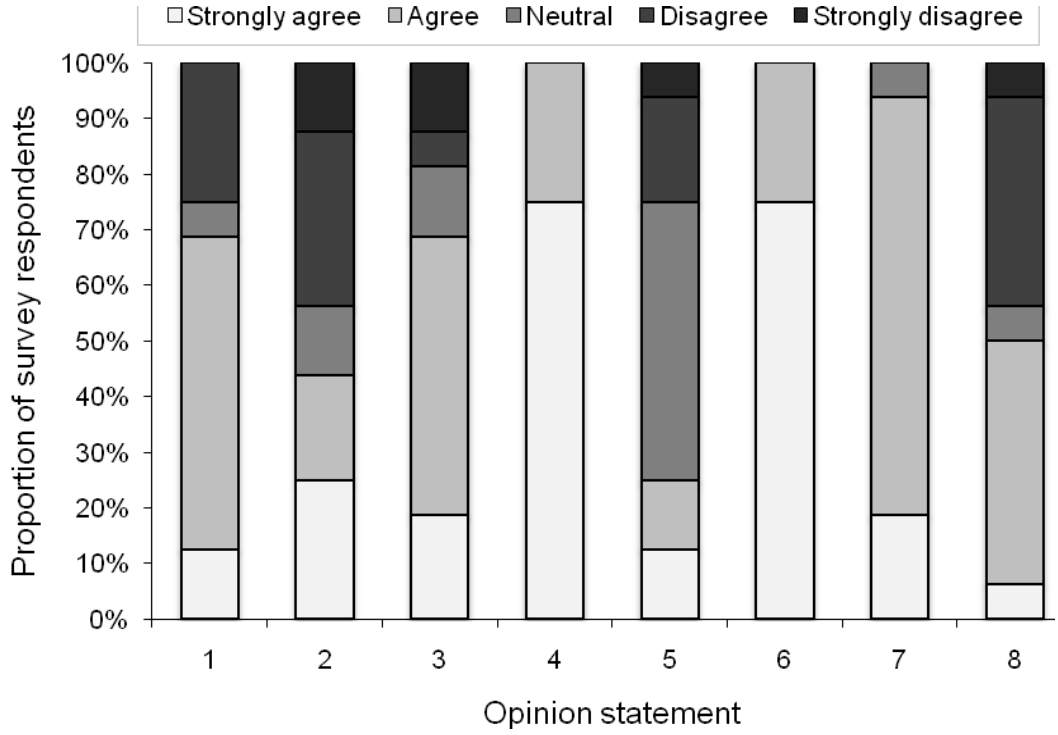


Figure 35. The opinions of Little Cayman survey respondents on whether a) the average quantity of fish and b) the average size of fish in catches had changed over time. Surveys were conducted on Little Cayman during February 2011 (n = 16).

When asked to rate the condition of the marine environment around Little Cayman on a scale of 1-10, the majority of survey participants (63%) chose a rating above 6 on the scale. The mean respondent rating was 7.3 (± SD 2.5).

88% of respondents supported the idea of marine environmental management, despite varying opinions on the current effectiveness of management around Little Cayman, and only one participant on Little Cayman was against management initiatives. All of the survey participants on Little Cayman agreed that a) conservation of coral reefs is important and that b) the marine environment of the Cayman Islands is valuable and should be conserved (Figure 36). The majority of participants held the view that marine parks around the island work well (94%), however, 44% of individuals who completed the survey voiced the opinion that enforcement of the marine parks and laws is inadequate. Many of the survey participants (69%) believed that areas closed to fishing would improve fishing elsewhere around the island and a notable proportion of fishers (44%) held the opinion that some species of fish around Little Cayman are overfished.



Statement	Description
1	The sea is not at risk from humans on the island
2	Some species on the island are overfished
3	Areas closed to all fishing will improve fishing elsewhere around the island
4	Conservation of coral reefs is important for the island
5	Resident fishers pose greater impact on the marine environment than sports fishers
6	The marine environment of the Cayman Islands is valuable & should be conserved
7	The MPAs on the island work well, are in good locations and are adequately sized
8	Enforcement of the marine protected areas around the islands is adequate

Figure 36. Opinions of Little Cayman survey participants to eight statements relating to the condition of the marine environment and current marine management around the Cayman Islands (n = 16).

3.3.3 Socio-demographics

14 of the 16 survey respondents on Little Cayman were male (87%), with only two female fishers interviewed, and 11 of the participants (69%) were Caymanian. The length of residency of survey participants on Little Cayman was highly variable (Table 3), and only 4 of the respondents had lived on the island for their entire lives. Four of the five expatriate participants originated from the United States and three of the five were employed as fishing guides. The majority of participants worked in the service industry and 75% of the surveyed population was below the age of 54.

3.4 Fishing Pressure from Tourists

One of the aims of the study was to quantify the recreational fishing activities of tourists visiting the Cayman Islands. During survey periods on the sister islands (Cayman Brac and Little Cayman), only a small number of tourists were encountered, few of which had engaged in fishing activities during their visit. Only two tourist questionnaires were completed on Cayman Brac and only four were conducted on Little Cayman. On all three islands, the majority of encountered tourists were either participating in dive activities during their vacation or had come to the islands to relax and take advantage of the ecotourism trips available. Not one cruise ship guest on Grand Cayman, that was approached, indicated that they were planning to fish during their time in the Cayman Islands, and the tourists that were engaging in fishing practices where those that had travelled to the island via plane.

On Grand Cayman, 32 tourist questionnaires were conducted during the 5-week survey period. 28 of the 32 tourists were visiting from the United States, two were from Canada and two from the UK. Tourists reported catching a total of 166 fish, 26 conch and 3 lobster during their time on Grand Cayman (Figure 37). Total catches of 124 reef fish (75% of total), 35 pelagic fish (21%) and 7 fish classed as 'other' (including tarpon, bonefish and elasmobranchs) were reported (4%). The mean catch of fish per person was 6.1 (± SD 9.6), and 12 of the 32 respondents were unsuccessful in catching marine life.

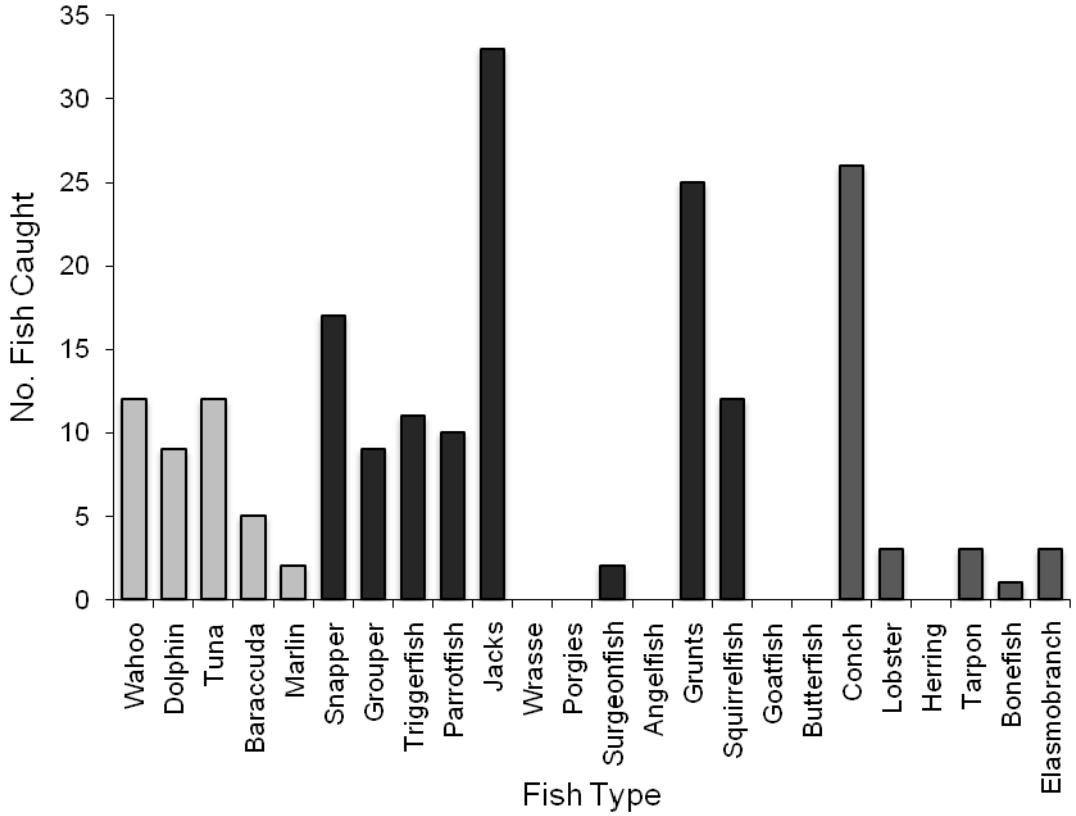


Figure 37. Total number of fish caught by tourists during their visit to Grand Cayman, as reported during fisheries surveys in February and March 2011 (n= 32). Light grey bars = pelagic species, dark grey bars = reef species, mid grey bars = 'other' species.

The mean number of days that interviewed tourists spent fishing while on the island was 3.0 (± SD 3.4), and on average individuals fished for 4-hour durations (± SD 1.5), releasing 46% of their catch back into the marine environment. For 41% of tourists, this trip was the first time that they had engaged in fishing activities in the Cayman Islands. 22% of respondents fished on Grand Cayman once every few years and 22% fished on the island once a year, with only a small proportion of the surveyed tourist population fishing in the Cayman Islands more frequently (16%).

A notable proportion of tourists fished from charter boat (44%), or from shore (41%), with only 9% of individuals fishing from private boats, and 6% fishing from a mix of platforms. The majority of tourists believed that their awareness of the marine parks was good, with 47% stating that they were 'aware' of the park system and 27% stating that they were 'highly aware'. However, the remaining 27% were unaware of the marine parks and restrictions.

Fewer tourist questionnaires were completed during the survey period than anticipated, owing to the difficulty in accessing this group at predicable times following fishing trips. Recommendations for further tourist fisheries surveys on Grand Cayman can be found in section 4.

3.5 Temporal Fisheries Comparison

A comparison of fisheries data collected in the current study was performed with data collected during a socio-economic pilot survey on Grand Cayman between June - July 2009 (Henshall, 2009), allowing investigation of seasonal and temporal differences in recreational fishing practices on the island. A greater number of fishers participated in the current study (n = 264) than during the study in 2009 (n = 172), however, the socio-demographics of the survey populations were similar between the two years. 94% of fishers in 2009 were male (n= 183) (compared to 96% in 2011), and 60% of respondents were Caymanian (compared to 63% in 2011).

Total fish catch over a monthly period in the current study was greater than that reported over the same duration in 2009 during the summer (Henshall, 2009) (Table 7), and while the total number of fish caught in the different fish groups differed between years, fishers targeted the same main reef fish, with snappers, triggerfish, grunts, parrotfish and jacks caught in greatest quantities (Figure 38). The proportional number of fish caught in different family groups did not differ between studies (Chi-square test, $\chi^2 = 18.034$, df = 15, $P > 0.05$).

Table 7. Summary of the characteristics of recreational and artisanal fisheries on Grand Cayman, according to information provided by fishers during marine fisheries questionnaires performed between February - March 2011 (Current study, n = 228), and between June-July 2009 (Henshall, 2009, n = 172).

Fisheries characteristic	**2009 (*Henshall, 2009)***	**2011 (*Current study*)**
Total fish catch	11,140	14,968
Reef species	10,358	13,220
Pelagic species	654	1,370
Other species	127	378
Mean catch (fisher month^{-1} ± SD)	61 (± 111)	72 (± 152)
Mean no. days fishing month^{-1} (± SD)	5.3 (± 6.4)	5.1 (± 6.5)
Mean proportion catch kept	88%	74%
Catch Per Unit Effort (no fish day^{-1})	14.4 (± 31.8)	12.4 (± 16.6)
Fishing platform		
Boat	92 (53%)	136 (62%)
Shore	23 (13%)	36 (16%)
Mixed	57 (33%)	48 (22%)
Reason for fishing		
For food	62%	36%
Source of income	16%	22%
Recreation	22%	42%

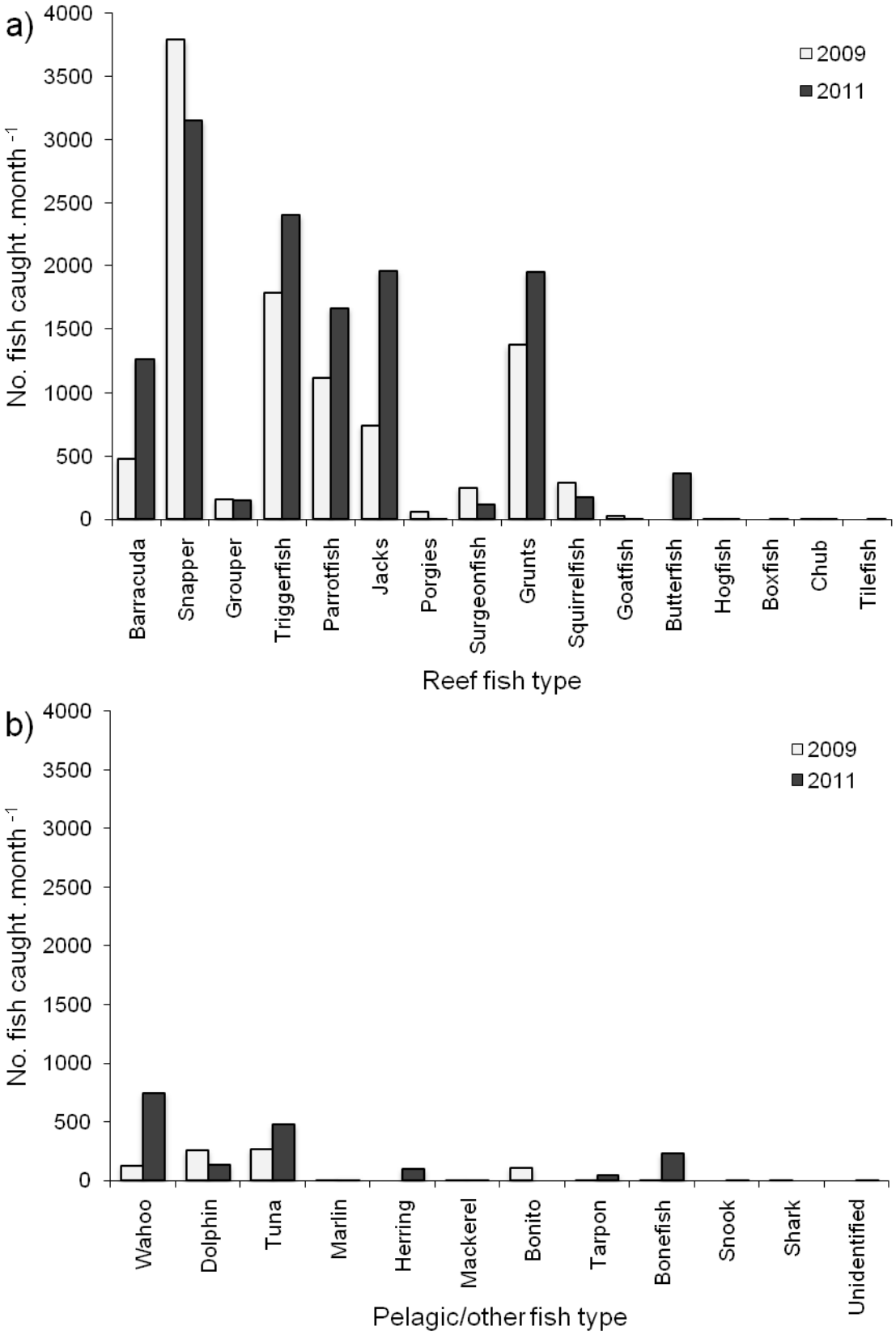


Figure 38. Abundance of a) reef fish and b) fish classed as either pelagic or 'other' species that were caught by recreational and artisanal fishers around Grand Cayman in a monthly period, according to information provided during fisheries questionnaires in 2009 (Henshall, 2009: n = 172) and 2011 (current study: n= 228).

A comparison of results revealed no major differences in fishing effort between survey periods. The median number of days respondents spent fishing during a month did not differ significantly between years (Mann-Whitney *U* test, $U = 21541.5$, $P = 0.05$), and the mean number of days that survey participants spent fishing was similar between the two surveys (Table 7). No significant difference in the median number of fish caught per fisher month^{-1} was found between 2011 and 2009 (Mann-Whitney *U* test, $U = 20746.0$, $P > 0.05$), or in median CPUE between survey participants in the two years (Mann-Whitney *U* test, $U = 20675.5$, $P > 0.05$).

In 2011 a larger number of individuals fishing from boat were encountered than in the pilot study, however no significant difference in the proportional number of respondents fishing from different platforms (arcsine square-root transformed) was detected (Chi-square test, $\chi^2 = 1.207$, df = 2, $P > 0.05$). A greater proportion of fishers engaged in fishing practices for recreation in the current study, in comparison to 2009 survey respondents, the majority of which fished for food (Table 7). When statistically tested on arcsine square root transformed data, however, this difference was non-significant (Chi-square test, $\chi^2 = 5.207$, df = 2, $P > 0.05$).

3.6 Illegal Fisheries

A dataset of marine conservation officer illegal incident reports and legal files spanning from 1993-2010 was analysed, to investigate trends in illegal fishing activity on Grand Cayman.

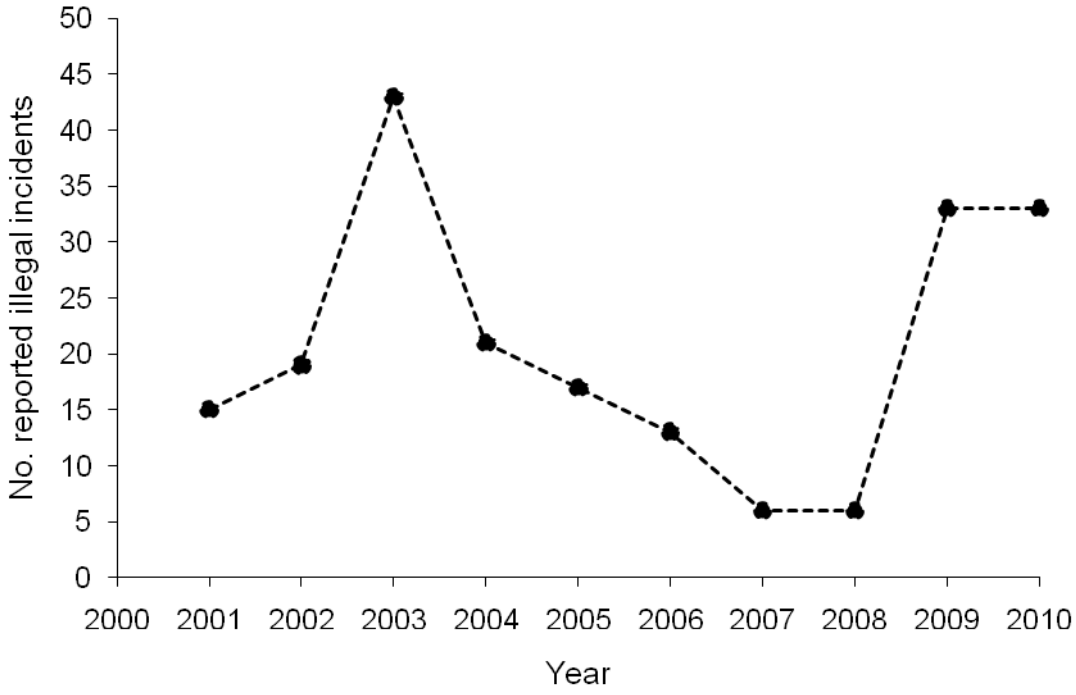


Figure 39. Temporal trend in the yearly number of reported illegal marine park incidents occurring around Grand Cayman.

Between 1993 and 2010, Department of Environment marine fisheries officers reported a total of 211 illegal marine park incidents and 439 individual marine park law violations. Between 1993-2000 only 4 incidents (10 marine park law violations) were documented, however, from 2001 documentation of incidents became more standard practice. Between 2003 and 2008 an overall decrease in the number of reported illegal incidents occurred (Figure 39), with a subsequent rise in 2009 and 2010.

Data were analysed for the four main marine faunal groups frequently seized by marine officers after being caught illegally. Incident reports indicated that conch (*S. gigas*) were the species illegally taken from marine parks in greatest numbers between 2001-2010, with 2090 individual conch seized during the period (Figure 40a). On a yearly basis, the total number of conch illegally seized varied widely (Figure 40b). The number of seized lobster remained relatively constant over time, as did numbers of illegally caught fish, excluding data for 2003 in which a record number of fish were confiscated (149 individuals) (Figure 40b). Incident reports further documented detection of seven poached turtles since 2001.

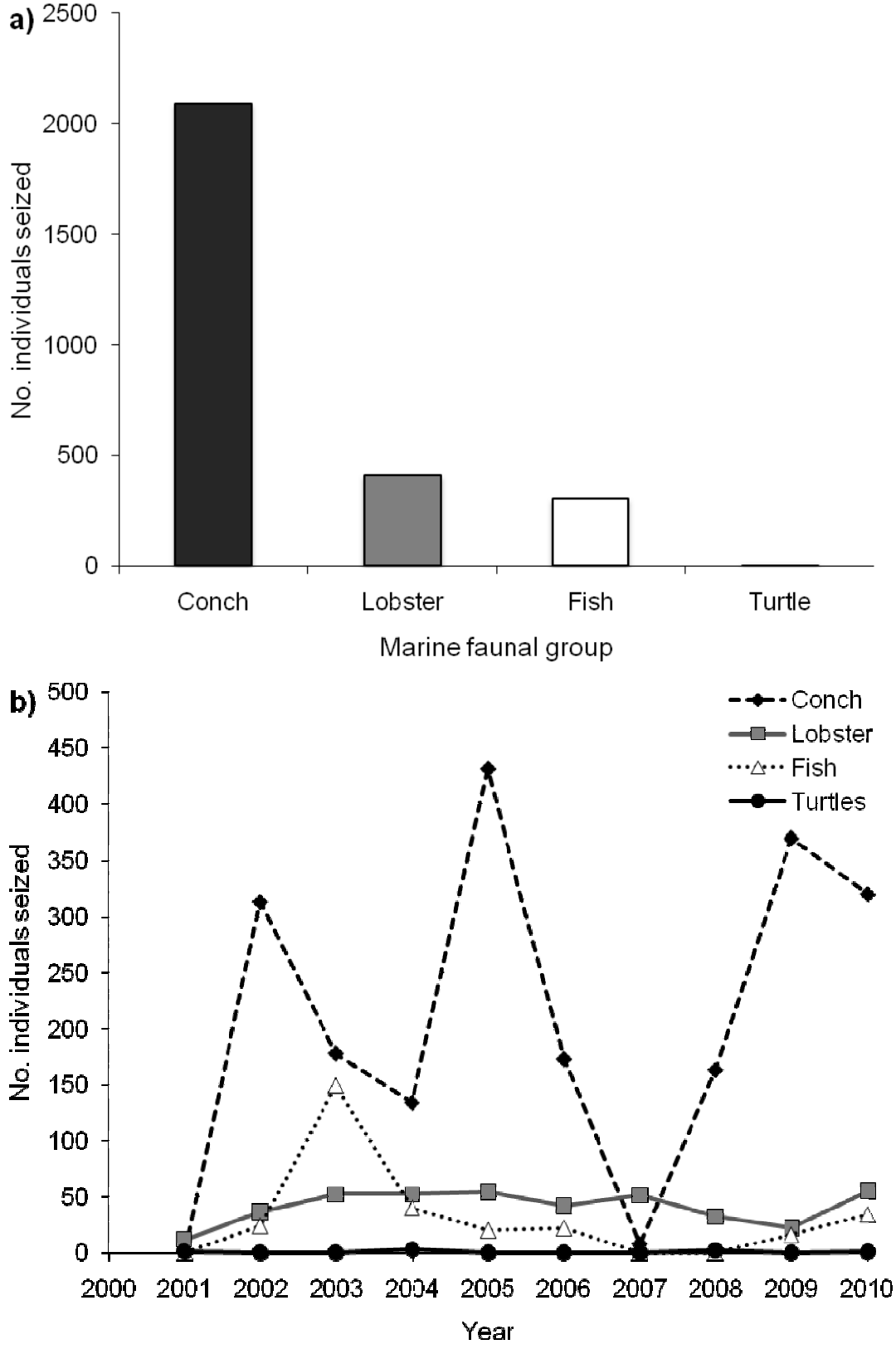


Figure 40. a) The total number of illegally caught marine organisms (sorted by marine faunal group) and b) the number of illegally caught marine organisms per year, reported in illegal incident documents by marine fisheries officers between 2001 and 2010.

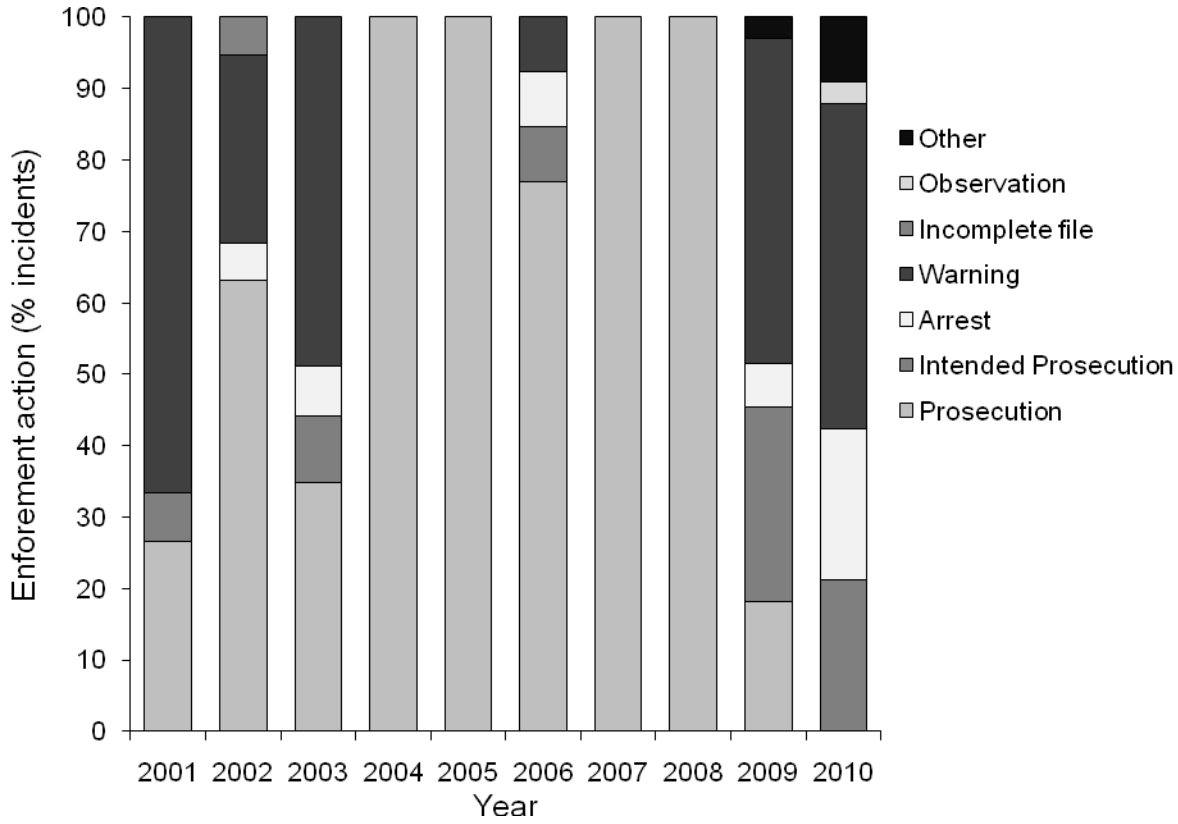


Figure 41. Number of reported illegal marine park incidents between 2001-2010. For each year, bars show the enforcement actions taken as a proportion of the total number of incident cases (n = 211).

The actions taken by marine officers, upon detecting a marine park violation, ranged from the issuing of warnings to the parties involved in an illegal incident, to arrests that often lead to prosecution and resulted in a monetary fine (of up to CI $500,000) or jail sentence. Other penalties involved forfeiture of equipment and vessels that were used during the offending act. Between 2004 – 2008 the majority of marine park violations terminated in court prosecution of offenders involved in the incident (Figure 41). However, in 2009 and 2010 a greater proportion of the actions taken by marine fisheries officers involved issuing warnings, or recommending prosecution for cases still awaiting court proceedings.

Analysis of the spatial distribution of marine park violations contained within incident reports, indicated that the George Town, North Side and West Bay districts were those around Grand Cayman that had experienced greatest pressure from illegal marine activity during the period of study (Figure 42). 'Possession of an unlicensed spear gun' was the marine park violation that occurred most frequently between 2001-2010 (Figure 43). Other violations that were frequently reported included 'taking of marine life from a marine park', 'taking of marine life with an unlicensed spear gun' and 'taking of conch above the daily limit' (Figure 43). A list of the main marine park violations can be found in Appendix 7.

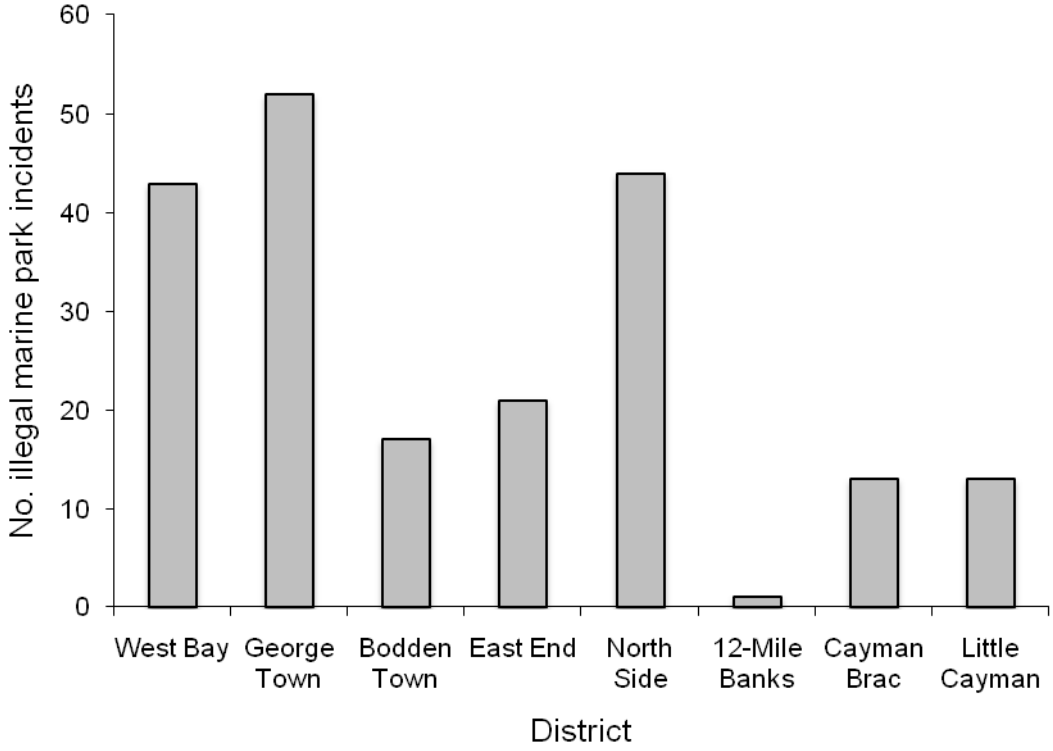


Figure 42. Total number of reported illegal marine park incidents between 2001-2010 sorted by the Department of Environment marine district (n = 204).

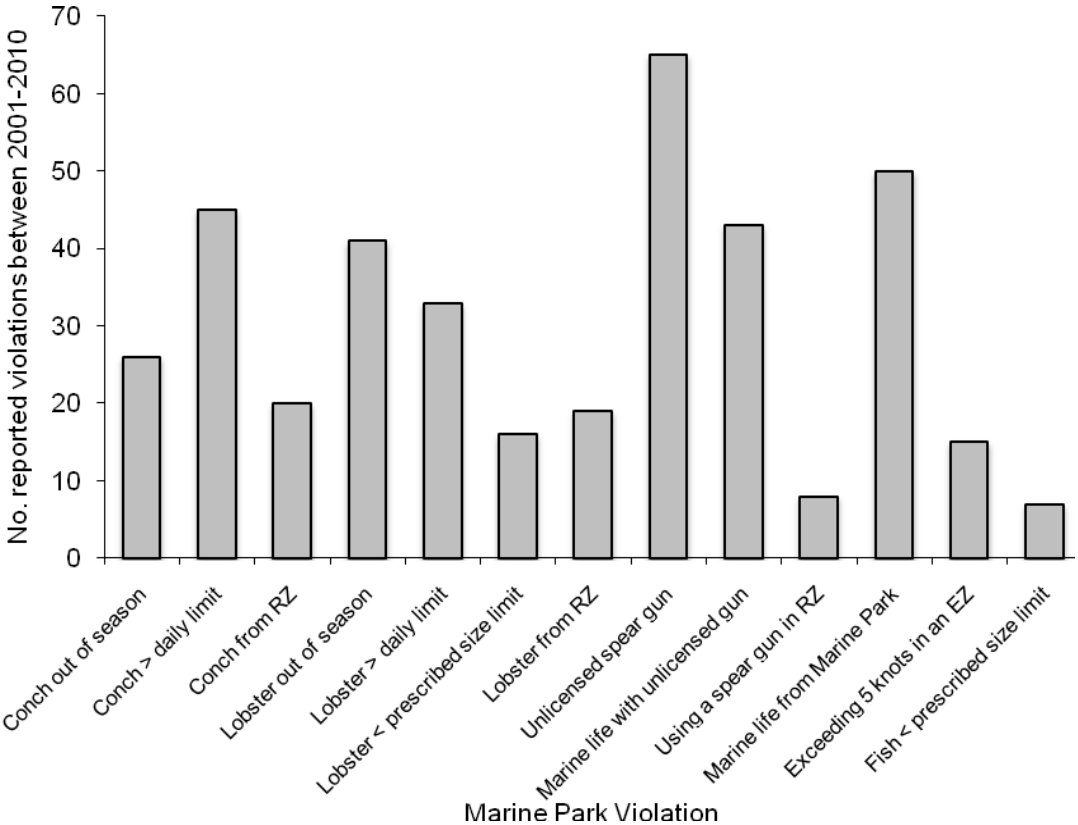


Figure 43. Frequency of occurrence of the most common marine park violations, reported by marine fisheries officers between 2001-2010 (n = 388).

4 DISCUSSION

This study has provided a comprehensive short-term assessment of fishing pressure around the Cayman Islands, which, combined with a pilot survey in

Photo: Fish cleaning at local boat ramp, Grand Cayman (M. Orr)

2009 (Henshall, 2009), provides evidence to suggest the existence of a significant fishery around the islands. The study yields additional information on the views of the fishing community towards marine environmental management and on factors influencing the behaviour and decision-making processes of fishers that could be applied to future management strategies.

Fishing Pressure on the Cayman Islands

In this study, notable fishing effort around the Cayman Islands is apparent, despite the lack of a commercial fishery and the scarcity of attention often afforded to artisanal and recreational fishing practices (Cooke & Cowx, 2004; 2006; Hawkins & Roberts, 2004; Morales-Nin et al. 2005). In a monthly period, fishers reported catching 14,968 fish on Grand Cayman and a total of 5205 fish on the Sister Islands, the majority of which were reef fish species.

To what extent fishing pressure has contributed to current ecosystem states around the Cayman Islands is difficult to determine due to the variety of factors believed to have influenced reef ecosystems over the last few decades and the apparent ecosystem shifts observed Caribbean wide (Gardner et al. 2003). Results of the present survey are concerning however, considering that, on Grand Cayman, herbivorous parrotfish were amongst the main fish groups exploited by fishers, with over 1600 fish reported as landed by surveyed fishers in a single monthly period. Removal of key functional groups on Caribbean reefs is believed to have contributed greatly to ecosystem alterations (McClanahan et al. 2002; Bellwood et al. 2004). In a similar way, excessive removal of certain fish groups on Caymanian reefs could influence the functioning of this ecosystem. Herbivorous fish in many areas of the Caribbean remained the major grazers of reef systems after loss of *D. antillarium* in the 1980s, and as urchin recovery has been slow, overfishing of key functional species could result in further change and loss of reef resilience (Hawkins & Roberts, 2004).

Snappers, a favoured reef fish for consumption in Cayman waters (Burgess et al. 1994), were the group caught in highest numbers by surveyed fishers on all three islands. Survey participants removed 4699 snappers in a monthly period on the three islands, a figure that is anticipated to be well below total monthly levels of snapper exploitation. This indicates heavy fishing pressure on this ecologically important group (Gobert et al. 2005), and a potential need for further protection measures of such exploited fish. Survey respondents indicated that yellowtail (*O. chrysurus*), mutton (*L. analis*) and mangrove snapper (*L. apodus*) were frequent targets, but as the questionnaires used in this study provided information at the family level only, regular collection of species-specific landings data is now required, to enable detection of any overexploitation at the species level. The large number of ocean triggerfish, jacks and grunts, caught by Caymanian residents participating in the survey, is consistent with existing reports on the popularity of these fish amongst fishers (Burgess et al. 1994). Survey participants did not indicate the extraction of groupers in large numbers in comparison to other commonly targeted reef fish species, which may be linked to long term restrictions

placed on grouper fishing at spawning aggregation (SPAG) sites, and an associated hesitation of the surveyed population to mention this group for fear of future repercussions. The exploitation of spawning aggregations in Caymanian waters remains a concern, however, due to the vulnerability of aggregating fish, which can be located and exploited with minimal effort (Sadovy & Domeier, 2005).

Photo: Ocean triggerfish caught on Cayman Brac (L. Richardson).

Barracuda were targeted in considerable numbers by both artisanal and recreational fishers during the survey period and while many recreational fishers reported releasing this species upon capture, due to potential health

issues associated with Barracuda consumption (Matta et al. 1999), mortality rates from catch-and-release practices are largely unknown (Cooke & Suski, 2005; Cooke & Cowx, 2006). Studies comparing reef fish communities at sites under varying levels of fishing pressure, have reported that removal of predatory fish can lead to changes in the structure of reef communities (Jennings & Polunin, 1997; Friedlander & DeMartini, 2002; Graham et al. 2003). Consequently, the level of exploitation of transient predators in Caymanian waters should represent an important management consideration.

Jennings and Polunin (1996b) suggested that removal of just 5% of fish biomass from reef ecosystems could result in notable change to reef fish community structure, and considering that, despite MPA conservation measures, some species of reef fish appear to take many decades before showing signs of recovery (McClanahan, 2000), removal of substantial numbers of fish from Caymanian waters may be significant. Overfishing is known to interact with other stressors, reducing the ability of reef ecosystems to deal with natural disturbance events (Roberts, 1995), and in an area of the Caribbean where hurricane disturbance is a regular occurrence, the necessity for effective fisheries management in the Cayman Islands is highly evident.

A comparison of reported fish catches on the three islands suggested that total fishing pressure, in terms of the number of fish extracted, was greater on Grand Cayman, with lowest pressure placed on fish populations around Little Cayman. However, the mean number of fish landed per person was similar for the two largest islands. This difference is not surprising considering the contrasting human population sizes of the islands and the disparity in numbers of fishers encountered between the three. Few fishers were encountered on Little Cayman, and the small population of the island indicates that fishing pressure may be relatively low. In addition to fishing in local waters, many Cayman Brac fishers reported travelling to Little Cayman to exploit the plentiful fish populations present there, which will elevate the impact from fishing. Fishing effort per month was higher on the Sister Islands than Grand Cayman, with a greater proportion of people fishing for food. In more remote island communities, such as the Sister Islands, where work opportunities are limited, fishing remains a dominant cultural activity, and a large number of fishers declared that despite fishing primarily for food they also use fish resources to supplement incomes. Such an enhanced understanding of the incentives to fish, and the associated behaviours of fishers, is essential when attempting to implement appropriate management measures (Richardson et al. 2005).

Analysis of information provided by survey participants indicated lower fishing pressure on pelagic species than reef fish. Reef species are targeted year round on the Cayman Islands, where many of the main exploited pelagic fish, such as wahoo, yellowfin tuna and dolphin, are migratory, occurring in peak numbers on a seasonal basis. Appropriate management should remain a priority for pelagic species, as they represent a notable target group and include fish such as the blue marlin (*Makaira nigricans*), reported to have undergone rapid declines in the tropical Atlantic (Myers & Worm, 2003), and

the yellowfin tuna (*Thunnus albacares*), currently near to or fully exploited in all oceans which they inhabit (Maguire et al, 2006). Highly migratory species, including tuna and billfish, can be vulnerable to overexploitation if fishery management is inadequate in multiple parts of their range, and as such cooperative management is required on a multi-national scale (Maguire et al. 2006). Further collection of data on pelagic fish catches by recreational and artisanal fishers throughout the year is highly recommended in the Cayman Islands due to the short-term nature of the current study.

Photo: Local fishers at the 2011 Rooster Shootout fishing tournament (R. Meier).

Fishing pressure analysis has highlighted that artisanal fisheries may be having a marked impact on reef fish populations around the Cayman Islands, which supports the work of Hawkins & Roberts (2004) who suggest that the

environmental impacts of artisanal fishing practices may not be as benign as often assumed. Spear fishing and beach seining, methods, which are both employed by artisanal fishers on the Cayman Islands, have been shown to cause direct physical damage to coral (Mangi & Roberts, 2006). Despite low reports of use by interviewed fishers these fishing practices may have the potential to cause additional reef habitat damage. Recreational fisheries may represent a further significant pressure on reef and pelagic fish stocks in this area of the Caribbean, which demonstrates a need to afforded more attention to this fishing sector on a wider scale (Cooke & Cowx, 2004; 2006).

Fisher behaviour for small-scale fisheries is generally poorly understood, however it is acknowledged that this behaviour has the potential to heavily influence management success and is therefore an important consideration for managers (Richardson et al. 2005; Abernethy et al. 2007; Hilborn, 2007). The spatial distribution of fishing effort was fairly restricted to key areas around the Cayman Islands. On Grand Cayman, areas of highest fishing effort aligned closely with the fringe reef, major shore access points and heavily populated districts. Many artisanal fishers were observed fishing in the North West Point area, and the prevalence of shore fishers targeting waters opposite the turtle farm, where fish are known to congregate, contributed greatly to the high levels of fishing effort recorded in this area. During preliminary surveys, Henshall (2009) noted that high fishing effort at North West point coincided with the location of MPA boundaries. It was suggested that this might indicate a distribution of fishing effort at reserve boundaries in attempts to exploit a spillover of fish biomass to non-protected waters, a behaviour previously reported around many MPAs (McClanahan & Mangi, 2000; Gell & Roberts, 2003; Russ et al. 2003; Stelzenmuller et al. 2008). Elevated fisher-effort around boundaries could undermine the benefits of MPAs (Roberts et al. 2005) and should be incorporated into future spatial planning around the Cayman Islands. While it is a plausible occurrence, future testing of spillover effects through biological sampling will be required, along with fine-scale surveys of fishing distribution.

The waters off of the East End of Grand Cayman also experienced heavier fishing effort than most, which can be explained by the presence of a remote community at this end of the island and a prevalence of artisanal fishing practices in this district. On both Cayman Brac and Little Cayman, fishers distributed their effort around the ends of the islands, and exploited local knowledge on the abundance of fish believed to congregate along the reef edge and shelf drop-offs in these locations. Fishing effort around the Sister Islands also aligned closely with Designated Grouper Spawning Areas, which may further indicate evidence of fishing along reserve boundaries. While this information is useful for future management, fishers in artisanal type fisheries are considered to have less-uniform and more heterogeneous patterns of behaviour than larger scale commercial fisheries (Salas and Gaertner, 2004), and do not always distribute themselves in an ideal way in relation to the location of resources due to the influence of complex external factors (Abernethy et al. 2007; Daw, 2008). Further investigation of the distribution of fishing effort is therefore recommended throughout the year around the

Cayman Islands to gain a better understanding of temporal variation in the behaviour of fishers.

In the current study the major selected factors influencing where fishers chose to fish were perception of where fish are abundant, weather conditions, and to a lesser degree on Grand Cayman distance from home. This information can be applied to future management in Caymanian waters, and is important to help predict the potential behavioural responses of fishers to future changes in MPA management (Abernethy et al. 2007), thereby reducing likelihood of fishing effort displacement to vulnerable, previously undisturbed areas (Dinmore et al. 2003; Roberts et al. 2005; Hiddink et al. 2006).

Lack of local support, low levels of compliance and insufficient enforcement have contributed to the failure of MPAs (Camargo et al. 2009; Pollnac et al. 2010), but in comparison to numerous management efforts around the globe, the MPA system around the Cayman Islands has experienced active enforcement and well-placed restrictions. Despite management efforts, illegal fishing practices remain an existing issue on the Cayman Islands. Analysis of enforcement records revealed that in the majority of years between 2001 and 2010, queen conch (*Strombus gigas)* were the organisms illegally caught and confiscated most frequently, followed by the spiny lobster (*Panulirus argus*). It is anticipated that for every individual caught engaging in illegal fishing, there are many more that are not encountered, and the illegal exploitation of species such as the conch, for which daily limits and closed seasons are already in place, is concerning due to their present conservation status and recently declining populations (Theile, 2005). Management and conservation measures for this species are believed to be undermined in many countries in the Caribbean, where landings and trade data are inadequate (Theile, 2005), and the current illegal removal of significant numbers of conch from Caymanian coastal waters identifies a need for improved management initiatives. Interestingly, fishers did not frequently report catching conch or lobster during surveys, which may reflect their sensitivity to existing government limitations placed on these organisms.

The number of reported illegal incidents was relatively low over time, considering the population on the Cayman Islands, but this may highlight the thin spread of resources allocated to the government enforcement team, who currently rely heavily on information provided by local informants, and a subsequent requirement for increased manpower to effectively police the MPA system. Many fishers commented during surveys that they regularly observed individuals breaking the law on the water and the most frequently occurring opinion was the current inadequacy of enforcement. In cases where enforcement resources are limited, efforts towards community education are recommended, to increase awareness of the benefits of protection, and improve local support and compliance (Roberts & Hawkins, 2000). Involvement of local stakeholders in marine management is being increasingly recognised as an important component for success (Pollnac et al. 2001). Community involvement has proved beneficial in MPA management in many countries (Russ & Alcala, 1999; Pollnac et al. 2001; Napier et al. 2005;

McClanahan et al. 2006), and in the Cayman Islands could be fostered with the creation of organised voluntary officer schemes to increase monitoring efforts around the marine parks, along with increased levels of public consultation during future reviews of the MPA system.

'Possession of an unlicensed spear gun' was the marine park violation that occurred most frequently between 2001-2010. Use of this fishing gear is currently prohibited under marine park regulations without possession of a license, issued by the DOE. Opposing opinions did emerge amongst some interviewed fishers, who believed that this traditional fishing practice should be allowed to continue and who saw the restrictions on spear gun fishing as unfair and the dissemination of licenses as bias. A handful of interviewed fishers on Grand Cayman held the opinion that prosecution for poaching has been too lenient, indicating that such individuals attached value to reef fisheries resources around the island and recognize the benefits of fisheries restrictions. Between 2004-2008 most marine park violations terminated in court prosecutions, although minimum sentences are often given to guilty parties, and many known offenders are repeatedly caught on similar charges with few signs of willingness to change (DOE fisheries officers, pers. comm.).

Photo: 218 conch illegally taken by poachers from a replenishment zone (M. Orr).

Many of the underlying reasons for reef degradation are complex and are linked to deeper social and economic conditions (Cinner et al. 2009a). During the present study, many respondents stated that they fish to feed their families during times when work is scarce and meat is expensive. Other

individuals who regularly take marine life in an illegal manner on Grand Cayman are known to do so to fuel drug and alcohol addictions (DOE fisheries officers, pers. comm.). Poverty is an issue, and studies have shown that poorer fishers can demonstrate less readiness to leave unsustainable depleted fisheries than those with greater wealth (Cinner et al. 2009b). Fishing is an important part of Caymanian culture, whether providing food, money or recreation to residents, and both the social and economic aspects of fishing should continue to be recognised by managers upon reviewing conservation strategies.

An 'integrated social-ecological approach' to fisheries management has been suggested as a more effective way to tackle the current levels of impact placed on reef systems (Bellwood et al. 2004; Cinner et al. 2009a). It has been stated that wider efforts are required to address unemployment, improve systems of governance, address issues associated with increasing population sizes and provide alternatives to those that rely largely on reef-associated incomes (Cinner et al. 2009a; 2009b). In the Cayman Islands, where underlying social issues are prevalent, steps toward a more integrated management approach may prove beneficial.

Socioeconomic Consideration for Management

The majority of fishers who participated in the survey supported the idea of marine management as a means to protect the Islands' marine resources and environment. Additionally, nearly all respondents on the three islands agreed that the marine environment of the Cayman Islands is valuable and that conservation of coral reefs is important. This should be viewed as encouraging given the accepted importance of community support and involvement for the successful implementation of MPAs as a conservation tool (Roberts & Hawkins, 2000). Despite widespread acknowledgement of the need for management, many opinions were voiced about the inadequacy and failings of the current management system on the Cayman Islands, providing information that can be used during future reviews and decision-making processes.

Fishers hold a wealth of knowledge about their fish resources, local environments and the fishing activities of their community (Neis et al. 1999; Scholtz et al. 2004). While human perceptions can be influenced by a number of factors, local fisher' knowledge can prove a useful untapped resource for management, as has been found on the Fijian islands in a study which utilized traditional knowledge to investigate the population status of the giant humphead parrotfish (Dulvy & Polunin, 2004), and in Newfoundland where information on fishing efficiency was obtained through structured interviews (Neis et al. 1999). Such informal approaches can provide historical information on species status, enhance knowledge on abundance and exploitation, help with the spatial planning of MPAs, and can be used to inform on appropriate directions for focused research (Neis et al. 1999; Johannes et al. 2000; Dulvy & Polunin, 2004). A notable proportion of fishers that participated in the current survey held the opinion that it has become

harder to catch fish over the years, with the abundance of fish in catches having declined over time. This opinion was held to a greater extent on Grand Cayman and Cayman Brac than on Little Cayman. While many fishers believed that this was true for all species, declines in tuna, wahoo and small reef fish were mentioned frequently. Nearly half of the questioned fishers also agreed that some species of fish are overfished around the Cayman Islands. Such knowledge, particularly provided by elderly members of the fishing community should be viewed as a useful source of information that can help better management of target fish stocks (Johannes et al. 2000).

The majority of surveyed fishers on the three islands agreed that the MPA system is working well, however on Grand Cayman and Cayman Brac more than half of the interviewed fishers believed that enforcement is inadequate. Many stated that the presence of enforcement officers on the water is minimal and that policing of the MPAs should be extended to cover night time periods when fishing is prevalent. Lack of resources for enforcement can be a large hindrance to the success of MPAs in areas where compliance is an issue (Watson et al. 1997; Clifton, 2003; McClanahan et al. 2006; Guidetti et al. 2008; Wilkenson, 2008). The fact that so many local fishers identify this issue should be enlightening, as it reinforces a pressing need to address this issue through a reallocation of resources, if the current system of marine management is to be successful. Alternatively, should community support for management measures become high and education become a priority, requirements for high levels of top-down enforcement may be lessened (Roberts & Hawkins, 2000; Gell & Roberts, 2002). Fishers who expressed a lack of compliance to MPA restrictions were also aware of the paucity of manpower available for enforcement and acknowledged taking full advantage of this information, which warrants concern. Current attitudes of fishers identified through this study therefore suggest that future efforts should be made to educate locals on the benefits of resource management. The need for additional steps to improve relations between resource users and managers is also evident.

The location of the marine parks around the islands was a controversial topic that arose through structured questionnaires. Some fishers stated that the parks had been left in the same areas for too long, and proposed the introduction of a rotational scheme. Other participants, especially in Cayman Brac expressed the opinion that the MPAs had not all been placed in appropriate locations. Fisheries and pollution are known to interact to cause stress on reef ecosystems through increased algal growth rates (McClanahan et al. 2002), and pollution was a common theme identified by fishers as being an issue on Grand Cayman that required improved management. Impacts from the dive industry and growing boat traffic were also believed to be problems in need of attention from managers.

In comparison to Grand Cayman and Little Cayman survey participants, a larger proportion of Cayman Brac fishers expressed negative feelings toward the existing management of the marine environment. Many fishers on Cayman Brac strongly believed that fishing is their heritage and remains a

way of life, and the subject of the marine restrictions was frequently met with frustration. A common viewpoint conveyed by Cayman Brac fishers was that managers had consistently failed to consult or involve local community members in management decisions. Some local fishers stated feelings of marginalisation and were resentful toward the government and as a result, low levels of investment in the MPAs were expressed. An 'us versus them' mentality (Roberts & Hawkins, 2000) was clearly present among a number of interviewed fishers, which needs to be addressed as the perceptions of stakeholders towards conservation strategies are a major factor influencing success (Gelcich et al. 2008). Management needs to be site specific (Salas & Gaertner, 2004), and this requirement is heightened in island systems where the socioeconomics vary greatly between communities, as on the Cayman Islands. Effective management strategies for one group of people may prove counterproductive with others due to differences in attitudes, as has been demonstrated through a recent temperate fisheries study (Richardson et al. 2005), signifying a need for management evaluation on a case-by-case basis.

Active community involvement in management processes has been demonstrated to increase compliance and improve the chance of successful outcomes (Napier et al. 2005). The implementation of community-based management approaches has been documented for small-scale fisheries in North and South America (Castilla & Defeo, 2001), and more widely in tropical and sub-tropical waters (Ruddle, 1998; Pollnac et al. 2001, Christie et al. 2002; Johannes, 2002; Cinner, 2005; McClanahan et al. 2006). In St Lucia, initial attempts to implement reserves failed when stakeholder consultation was low, but high levels of community involvement and support have subsequently contributed to favourable management outcomes (Roberts & Hawkins, 2000). Community involvement is not the only determinant for the success or failure of conservation efforts however, and complex socioeconomic factors deserve consideration, such as local population size, the level of perceived threat from declining resources, the availability of alternative incomes, training resources, levels of government input, wealth and the length of time management restrictions have been in place (Pollnac et al. 2001; Pelletier et al. 2005, McClanahan et al. 2006; Camargo et al. 2009; Pollnac et al. 2010). Improving the understanding of the perspectives of fishers and of factors influencing their behaviour will ensure better relations between managers and resource users in the Cayman Islands, and should help to predict likely sources of future opposition for conservation policies (Salas and Gaertner, 2004; Scholz et al. 2004).

The partitioning of fishing effort from different sectors of the fishing community is a factor worth consideration, in light of increasing populations. A large expatriate and migrant worker community exists on the Cayman Islands, most notably on Grand Cayman, and to what degree these groups contribute to fishing pressure is of interest to management. Equally important is an ability to predict fishers' responses to future management implementations, which can arise through a better understanding of the views held by different groups of fishers (Richardson et al. 2005). It has been stated that resources users, not indigenous to an area, can cause environmental disturbance due to a lack of

local knowledge of ecological systems, inappropriate technology and short-term levels of investment (Cassels et al. 2005). In the Galapagos for example, introduction of new fishing techniques by migrants cumulated in an over-exploited fishery (Bremner & Perez, 2002). Results of the present study provide no evidence to suggest that non-Caymanian fishers are any more destructive in their fishing habits than Caymanians. Instead on Grand Cayman, non-Caymanian fishers reported lower catch rates than Caymanian survey participants, with less reliance placed on fish for food than native fishers. However, expatriate and migrant fishers comprise a significant proportion of the fishing community, and their extractive practices, along with those of native populations should be managed effectively. As is suggested by Kramer et al. (2002), overall population growth as a result of migration, rather than differing migrant fishing behaviour, may be the bigger concern.

It is also plausible that migrant fishers interviewed in the current survey misrepresented their fishing behaviour due to current restrictions placed on their resource use. Caribbean migrant fishers not originally from the Cayman Islands, rated the marine environment in better condition around Grand Cayman, than Caymanian and other expatriate fishers, and the overall views of this group differed significantly from the other two sectors of the fishing community. This indicates differing perceptions of what constitutes a healthy marine environment and the value placed on such. Many Caymanian fishers blamed the current state of fish populations on the migrant community, stating that Filipino and Jamaican fishers were responsible for declining fish stocks, due to the removal of small juvenile reef fish, and posed a continued threat to the environment. Such claims are difficult to substantiate, and may be motivated by cultural bias, however migrant fishers were observed extracting reef fish below or near to the minimum size limit on a number of occasions during the survey. Many local fishers identified the benefits of protecting immature fish and suggested that further increase of minimum landing sizes should be introduced, along with improved enforcement of the existing eight-inch size limit. Increasing population sizes were further seen as a threat to the islands' marine resources, which could play a part in fostering local support for reserves and self-enforcement should there be a perceived threat to livelihoods (Roberts & Hawkins, 2000). The complex social dynamics at play on the islands and the future challenges faced by managers are highly evident, as is the crucial need to incorporate socioeconomic considerations into management processes (Richardson et al. 2006).

On the Cayman Islands, the reefs are an important draw to visitors. Diver preference questionnaires performed in the Caribbean (Williams & Polunin, 2000) have demonstrated the importance of reef fish attributes to the overall dive experience of tourists. Therefore, in addition to the potential ecological impacts posed by unsustainable fishing, the negative economic effects of ecosystem degradation on the dive industry should be considered, in scenarios where dive experiences become less favourable.

Limitations and Future Survey Recommendations

As this survey was conducted over a two-month period it captures a limited snapshot of fishing pressure. While many reef fish species are habitat-associated and permanently reside in the coastal waters of the Cayman Islands, pelagic species such as wahoo (*Acanthocybium solandri*) and dolphin (*Coryphaena hippurus)* are migrational. Fishing activities are seasonal on the Cayman Islands and are related largely to the timing of fish runs and weather. During the survey period, the Cayman Islands experienced an extensive period of high winds and rough sea states, which is likely to have caused lower fishing pressure than would have taken place under milder conditions. Further quantification of catch size and CPUE is subsequently recommended at regular intervals throughout the year to gain measures of seasonal variation in fishing pressure on the three islands. Initial comparisons of fishing pressure in the current study with data collected during 2009 (Henshall, 2009), revealed no significant difference in the composition of fish catches or in fishing effort. However, reports of the total number of fish caught in the two studies did differ. While this may be an indication of varying sample sizes, it may also indicate temporal variation in fishing, reinforcing the need for further research.

A large proportion of Caymanian residents are known to fish (estimates of at least 10% of the Grand Cayman population were provided by DOE staff), and only 0.6% of Caymanian residents were encountered during the survey period. As such, total recorded catch sizes are likely to be considerable underestimates of true fishing pressure exerted by the total fishing population on the Cayman Islands. For safety reasons, most surveys were conducted during daylight hours. Night fishers and those fishing during dawn in remote areas may therefore be underrepresented in the data. This group of the fishing population could be more thoroughly targeted in future surveys using teams of surveyors to both increase sampling effort and minimise safety risks. It is also possible that fishers who were not encountered during this study, such as poachers and migrant workers, are responsible for extracting a significant proportion of reef fish from Caymanian waters.

Due to the length of questionnaires used in this survey and difficulties experienced in persuading many local fishers to participate, precise catch data were not obtained at the species level. This would be useful information in the future to gain a better understanding of the species facing unsustainable pressure from fisheries and could be obtained via the use of short monthly landing surveys disseminated within the fishing community.

Less than 40 tourist questionnaires were completed during the study period, identifying a need for future surveying of this population via alternative means, to ensure that a thorough assessment is made of fishing pressure exerted by Cayman Islands visitors. By the end of the survey period a number of boat captains had stated that they would have been happy to keep questionnaires on board charter vessels and request that tourists complete the survey during the return journey to shore, following a charter trip. Such a pre-organised arrangement between charter operators and DOE may prove beneficial in the future, and help to improve community involvement and collaboration. Future survey effort at local airports is also recommended.

Due to the close proximity of the Sister Islands, many fishers from Cayman Brac travel regularly to the waters around Little Cayman to fish. A number of interviewed Cayman Brac fishers had fished on both islands during the time period encompassed by this study, and as a result fish catches reported on the sister islands are not entirely independent.

The honesty of survey respondents may have been an issue during the study, particularly with individuals to whom fishing is restricted and those prone to poaching. While in some cases the reliability of the data was easily assessed, the honesty of participants was mostly difficult to judge. Many individuals reacted with caution and suspicion when approached, and it was necessary to build a rapport between surveyor and respondent prior to initiating the survey. Some fishers on Cayman Brac were highly reluctant to talk to surveyors, and questioned the motives for the questionnaire. Incidents also occurred where fishers quickly became angry upon being approached, stating that information that had been provided to researchers in the past had been used against the local community, causing changes to be made that they believed were not in their interests and for which they could see no benefit. While the majority of surveys were conducted independent of DOE staff, a DOE vehicle was provided as a mode of transport around Grand Cayman. Every effort was made to be discrete during surveys, but the nearby presence of a Government vehicle may have influenced the responses of fishers due to fears of repercussions should information provided be used by DOE. The use of unmarked vehicles and Bangor University name badges is therefore recommended during any future studies of a similar nature.

In conclusion, this study has enhanced existing knowledge on levels of fishing pressure around the Cayman Islands, highlighting the occurrence of significant reef fish extraction over short time scales, and key target groups at potential risk from fishing. Information provided during structured questionnaires has helped to determine the short-term spatial distribution of fishing effort, and has elucidated the nature of attitudes held by many local fishers, the motives for fishing, and the factors influencing behavioural decisions, knowledge of which is crucial for successful management implementation. This study has additionally identified areas in need of further research and fisheries monitoring, and contains information that could be beneficial during management re-evaluations. Future attempts to evaluate the MPA systems of the Cayman Islands should consider key social, economic and cultural aspects of resource use, alongside ecological knowledge. An improved understanding of the behaviours of fishers, and of the underlying socioeconomic drivers for fishing is essential to success, and it is hoped that this work, along with other recent surveys, provides initial information that can be used to this purpose.

ACKNOWLEDGEMENTS

Authors wish to thank the people of Grand Cayman, Cayman Brac and Little Cayman who participated in this survey. Thanks also to the owners and staff of Kirk Marine, Brown's Marine and local restaurant bars, along with the organizers of the Grand Cayman 2011 Rooster Shootout fishing tournament, who allowed questionnaires to be conducted on their premises. Additional acknowledgement is given to DOE marine fisheries officers (Mark Orr, Carl Edwards, Ronnie Dougall and Stuart Turpin) who provided logistical support in the field, and to GIS officers (Jeremy Olynik & Steve Schill) who created the spatial maps contained within this report.

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Photo: Empty conch shells at Cayman Brac boat ramp (R. Meier)

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APPENDICES

Photo: Evidence of local fish extraction, Little Cayman (R. Meier)

Appendix 1. DOE leaflet outlining the marine park regulations and marine conservation laws of the Cayman Islands.

SUMMARY OF CAYMAN ISLANDS MARINE CONSERVATION LAWS

LOBSTERS

- **Closed season:** 1 March through 30 November. No one may take lobster from Cayman waters during these months. No one may purchase, receive or possess lobster taken from Cayman waters during these months.
- **Open season catch limit:** Three per person or six per boat per day, whichever is less.
- **Size limit:** Six inch tail minimum size.
- Only spiny lobster (*P. argus)* may be taken.

CONCH

- **Closed season:** 1 May through 31 October. No one may take conch from Cayman waters during these months. No one may purchase, receive or possess conch taken from Cayman waters during these months.
- **Open season catch limit:** Five per person or ten per boat per day, whichever is less.
- No one may purchase or receive more than five conch from Cayman waters in any one day.

WHELKS

- **Closed season:** 1 May through 31 October. No one may take whelk from Cayman waters during these months. No one may purchase, receive or possess whelk taken from Cayman waters during these months.
- **Open season catch limit:** Two-and-a-half gallons in the shell or two-and-a-half pounds of processed whelks per person per day.
- No one may purchase or receive more than two-and-a-half gallons in the shell or two-and-a-half pounds processed whelks from Cayman waters in any one day.
- Chitons, periwinkles and bleeding teeth may not be taken from Cayman waters at any time.

ECHINODERMS

- Echinoderms (includes starfish, sea eggs/urchins, sea cucumber and sand dollars) may not be taken from Cayman waters at any time.

TURTLES

- No one may disturb, molest or take turtles in Cayman waters without a licence from the Marine Conservation Board.
- Possession of turtle eggs is prohibited.
- For licensed fishermen, closed season runs from 1 April through 30 November..

SHARKS

- No one may feed, attempt to feed or provide or use food to attract any shark in Cayman waters.

NASSAU GROUPERS

- **Size limit:** Twelve inch minimum size limit applies throughout Cayman waters year round **EXCEPT**:
- **Designated Grouper Spawning Areas are protected.**
- No one may take Nassau grouper from any of the Designated Grouper Spawning Areas from 1 November through 31 March.
- No one may spearfish or set a fish-pot within a one–mile radius of any Designated Grouper Spawning Area from 1 November through 31 March.
- No one may use a speargun to take Nassau Grouper.

OTHER FISH

- **Protected fish:** Jew fish, tilefish (whities), filefish (pipers) and angelfish, including Grey, French and Queen angels (old monks), may not be taken from Cayman waters at any time.
- **Size limit:** Eight-inch minimum size on all other fish except goggle eyes, herrings (including sprats), anchovies and silversides (including loggerhead and fine fry).

FISH POTS

- Must be licensed by the Marine Conservation Board.
- Only Caymanians over 18 may be granted licences.
- Only two pots per family and pots must be identified with a DOE tag.
- No fish pot may be set within a one–mile radius of any Designated Grouper Spawning Area from 1 November through 31 March.

SPEAR GUNS & SEINE NETS

- No one may use a speargun (includes Hawaiian sling, polespear, harpoon, hookstick or any device with a pointed end which may be used to impale, stab or pierce any marine life but does not include a striker) or seine net without a licence from the Marine Conservation Board. NOTE: A striker is defined as a wooden pole, at least 10ft long, with a maximum of 2 barb-less prongs attached to one end.
- No one may possess a speargun without a licence.
- No one may import a speargun or any parts for a speargun.
- Only Caymanians over 18 may be granted licences.
- **Speargun catch limit:** Three fish per licensed person per day.
- No one may use a speargun in water less than 20ft deep.
- No one may possess more than six fish that have been caught by a speargun.
- No one may spearfish within a one–mile radius of any Designated Grouper Spawning Area from 1 November through 31 March.
- Licence holders must carry licence when using seine net or spear fishing and adhere to licence conditions.
- No one may use a speargun to take Nassau Grouper.

FISHING LICENSES

- Unless licensed by the Marine Conservation Board, residents who do NOT possess Caymanian Status may not take or attempt to take, by any means, any marine life while he is on shore or in any part of Cayman waters in which he can stand.
- No licence is required for catch and release fishing.

GENERAL RULES

- Damaging coral by anchor, chains or any other means **ANYWHERE** in Cayman waters is prohibited.
- No taking of **ANY** marine life alive or dead while on SCUBA.
- No taking of any coral, sponges, etc. from Cayman waters.
- Wearing gloves while diving or snorkelling in Cayman waters is prohibited.
- Export of live fish or other marine life is prohibited.
- Fishing with gill nets, poison or other noxious substances is prohibited.
- Dumping **ANYTHING** in Cayman waters is prohibited.
- The export of more than three conch shells and or any black coral requires a CITES permit, issued through the DOE.

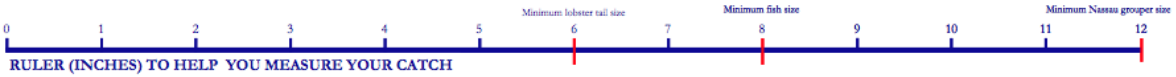
PENALTIES

Violation of any of these laws is an offence carrying a maximum penalty of CI$500,000 fine and one year in jail. Upon conviction, forfeiture of the vessel or other equipment may also be ordered.

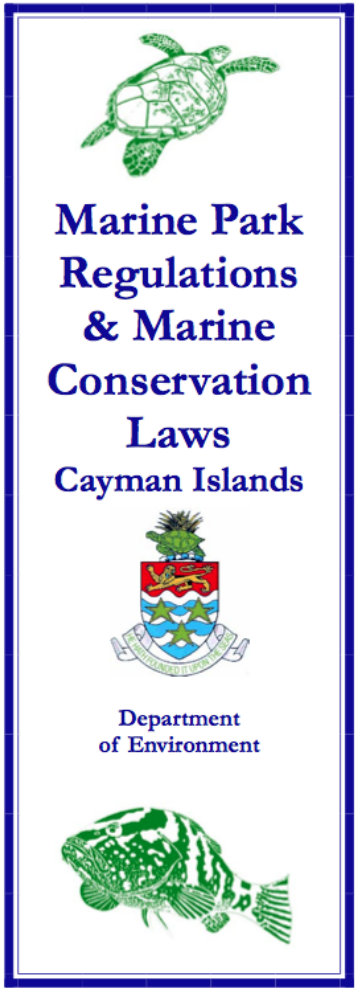
For additional information contact the Department of Environment
580 North Sound Road, Grand Cayman
Phone: 949-8469 Fax: 949-4020

Report Offences to:
Grand Cayman: 949-8469 or 916-4271
Cayman Brac: 926-0136
Little Cayman: 916-7021 or 926-2342
VHF: Channel 10
Or 911

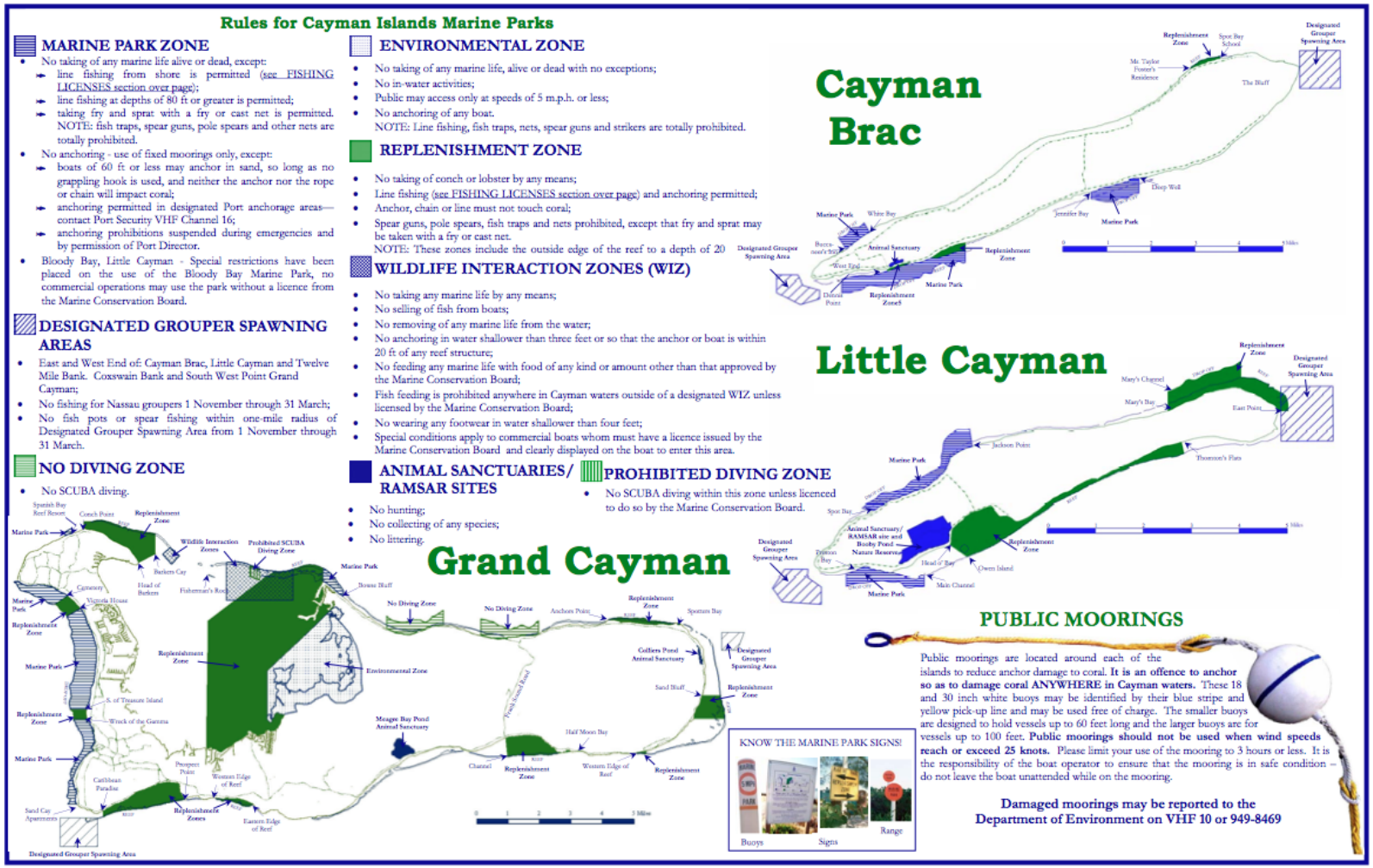
Report oil spills or other marine pollution to the DOE 949-8469 or 911
EMAIL: doc@gov.ky



RULER (INCHES) TO HELP YOU MEASURE YOUR CATCH



Appendix 1 (*continued*).



Appendix 2a. Resident questionnaire directed at fishers on Grand Cayman, Cayman Brac and Little Cayman during the current study in February and March 2011.

Characteristics of the Fishery of Grand Cayman: Resident Questionnaire

This survey is part of scientific research being performed to investigate the characteristics of recreational fishing on Grand Cayman. Answers are anonymous and confidential, and only aggregated data will be used for analysis. Your cooperation in answering these questions is appreciated.

Today's Date……..…….
Survey Location……..

RECREATIONAL FISHING IN GRAND CAYMAN

1. How often do you fish in the Cayman Islands?

Daily		Yearly	
Weekly		Once every few years	
Monthly		First time	

2. Over the last month, what percentage of your time recreationally fishing did you spend using the following fishing methods?

Fishing Method	% of time
Hook and Line from the shore	
Hook and Line from a boat	
Pot	
Spear Gun	
Seine net	
Other	

3. Over the last month, how many of the following species have you caught?

Species	Number	Species	Number
Wahoo		Parrotfish	
Dolphin		Grunts	
Tuna		Squirrelfish	
Marlin		Goatfish	
Barracuda		Angelfishes	
Grouper		Triggerfishes	
Snapper		Surgeonfish/Docta	
Wrasse		Conch/Lobster	
Porgies		Other (please state)	
Jacks		Don't know	

4. Approximately how many days in total have you spent recreationally fishing this month?

Days	

5. Approximately how many hours during a days fishing outing do you spend with your gear in the water?

Hours	

6. For how many years have you been fishing on Grand Cayman?

1-5		31-40	
6-10		41-50	
11-20		Over 50	
21-30			

7. Over the last month, what percentage of fish caught have you released back into the sea?

	% kept
	% released

8. Which one of the following is your main reason for recreationally fishing?

For food	
Supplement income	
Social activity	
Other	

9. On average, when do you go fishing?

Weekend morning	
Weekend afternoons	
Weekday mornings	
Weekday afternoons	
At night	

10. During the last month, which squares have you fished in, and which square have you spent the most time fishing in? (**refer to map**)……

11. Compared with previous years, do you think the average <u>quantity</u> of fish caught on an 'average' trip has changed this year?

Increased greatly	
Increased slightly	
Not changed	
Decreased slightly	
Decreased greatly	
Don't know	

If 'yes' have you noticed this with any particular fish species?.....

12. Compared with previous years, do you think the average <u>size</u> of fish caught on an 'average trip' has changed this year?

Increased greatly	
Increased slightly	
Not changed	
Decreased slightly	
Decreased greatly	
Don't know	

If 'yes' have you noticed this with any particular fish species?.....

VIEWS AND VALUES

13. What factors influence the location that you go to fish in?

Distance from home	
Abundance of fish	
Managed zones	
Weather/Tides/Currents	

14. How would you rate the condition of the marine environment on a scale of 1-10 (1 being very poor and 10 being outstanding)

Poor Outstanding

15. How do you feel about the current management of the marine environment around the Cayman Islands?

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16. Please indicate the extent to which you agree or disagree with the following statements

Statement	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The sea is not at risk from humans on Grand Cayman					
Some species on the Cayman Islands are overfished					
Areas closed to all fishing will improve fishing elsewhere around Grand Cayman					
Conservation of coral reefs is important for Grand Cayman					
Resident fishers pose more of an impact on the marine environment than sports fishers					
The marine environment of the Cayman Islands is valuable and should be conserved					
The marine parks around Grand Cayman work well, are in good locations and are adequately sized					
Enforcement of the marine protected areas around the Cayman Islands is adequate					

SOCIO-DEMOGRAPHICS

17. Gender

Male	
Female	

18. Age

<18		45-54	
18-24		55-64	
25-34		65-74	
35-44		75+	

19. Where were you born? ……

20. What do you currently do as a job? ……

21. How long have you been resident in the Cayman Islands?

Less than a year		11-25 years	
1-5 years		25+ years	
6-10 years		Entire life	

Appendix 2b. Tourist questionnaire directed at fishers during the current study in 2011.

Characteristics of the Fishery of Grand Cayman: Tourist Questionnaire

This survey is part of scientific research being performed to investigate the characteristics of recreational fishing on Grand Cayman. Answers are anonymous and confidential, and only aggregated data will be used for analysis. Your cooperation in answering these questions is greatly appreciated.

Today's Date……..…….
Survey Location……..

1. Is this your first time visiting Grand Cayman?

Yes	
No	

2. How did you reach Grand Cayman?

Flight	
Cruise Ship	
Other (please specify)	

3. How long will be the total duration of your current visit to Grand Cayman?

Number of days	

RECREATIONAL FISHING IN GRAND CAYMAN

4. How often do you fish in the Cayman Islands?

On a month basis		Once every few years	
Multiple times a year		First time	
Once a year			

5. What type of fishing have you taken part in whilst on Grand Cayman?

Charter Boat	
From the shore	
Private boat belonging to friend/relative	
Other	

6. During your recent visit to Grand Cayman, approximately how many days did you spend recreationally fishing?

Days	

7. Approximately how many hours during a days fishing outing do you spend with your gear in the water?

Hours	

8. During your stay on Grand Cayman, how many of the following species did you catch?

Species	Number	Species	Number
Wahoo		Parrotfish	
Dolphin		Grunts	
Barracuda		Squirrelfish	
Grouper		Goatfish	
Snapper		Angelfishes	
Jacks		Triggerfishes	
Wrasse		Surgeonfish/Docta	
Porgies		Conch/Lobster	
Other		Don't know	

9. During your time fishing on Grand Cayman, what percentage of fish did you release back into the sea?

	% kept
	% released

10. What percentage of the fish that were kept were you allowed to take home with you?

	%

11. During your recent visit, which squares have you recreationally fished in and which square did you spend most time fishing in? (**refer to map**)…….

VIEWS AND VALUES

12. How would you rate the condition of the marine environment on a scale of 1-10 (1 being very poor and 10 being outstanding)

Poor Outstanding

13. How do you perceive the current management of the marine environment of Grand Cayman?.....
……..

14. As a tourist on Grand Cayman, how aware were you of the different management zones of the marine environment?

Very Aware		Not Aware	
Aware		Don't know	

15. Please indicate the extent to which you agree or disagree with the following statements:

Statement	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The sea is not at risk from humans on Grand Cayman					
Some species on the Cayman Islands are overfished					
Areas closed to all fishing will improve fishing elsewhere around Grand Cayman					
Conservation of coral reefs is important for Grand Cayman					
Resident fishers pose more of an impact on the marine environment than sports fishers					
The marine environment of the Cayman Islands is valuable and should be conserved					
The marine parks around Grand Cayman work well, are in good locations and are adequately sized					
Enforcement of the marine protected areas around the Cayman Islands is adequate					

SOCIO-DEMOGRAPHICS

16. Gender

Male	
Female	

17. Age

<18		45-54	
18-24		55-64	
25-34		65-74	
35-44		75+	

18. Where were you born? ……

19. What do you currently do as a job?.....

Appendix 3. Summary of SIMPER outputs from √-transformed fish catch abundance data listing the average dissimilarity that snapper contributed to overall dissimilarity between fishing platform categories for Grand Cayman (n = 263) and Cayman Brac respondents (n= 58).

Fishing platform	Av. Dissimilarity	Ratio	Contribution (%)
Grand Cayman			
1 & 2	18.12	0.91	19.32
1 & 3	14.95	0.80	16.64
2 & 3	18.39	0.92	20.19
Cayman Brac			
1 & 2	23.97	0.88	28.19
1 & 3	26.20	0.95	28.58
2 & 3	29.45	1.15	34.24

Appendix 4. The proportion of the total respondent fishing visits around Grand Cayman in each grid square of the map, for a) reef and pelagic fishers (n: reef fishers = 81, pelagic fishers = 308) and b) boat and shore fishers (n: boat fishers = 466, shore fishers = 67).

a)

Map square	1	2	3	4	5	6	7	15	16	17	18	19	20	21	22	23	25	26	27	28	29	30
Pelagic	16	16	2	9	1	0	0	4	4	4	2	1	0	0	1	0	1	1	1	1	1	0
Reef	3	3	0	1	0	0	0	0	11	10	7	5	3	3	2	1	0	4	2	1	0	0
Map square	**31**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	
Pelagic	0	9	1	1	2	4	0	0	0	0	1	7	1	1	1	1	1	1	0	0	0	
Reef	0	5	1	0	8	8	2	1	3	5	1	5	0	0	1	1	1	1	0	0	0	

b)

Map Square	1	2	3	4	5	6	7	15	16	17	18	19	20	21	22	23	25	26	27	28	29	30
Boat	11	11	1	4	0	1	1	1	8	5	5	4	2	2	2	1	0	2	1	1	0	0
Shore	0	0	0	0	0	0	0	0	18	12	4	1	1	1	1	0	0	9	3	0	0	0
Map Square	**31**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	
Boat	0	8	1	0	3	7	0	1	1	2	1	7	0	0	1	2	1	1	0	0	0	
Shore	0	4	0	0	18	7	7	0	3	4	0	3	0	0	0	0	0	0	0	0	0	

Appendix 4c). The proportion of the total respondent fishing visits around Cayman Brac in each grid square of the map, for reef and pelagic fishers (n: reef fishers = 46, pelagic fishers = 16).

Map square	8	9	10	11	12	13	14	15	16	17
Pelagic	6	13	38	13	0	0	0	19	13	0
Reef	9	17	7	20	11	11	9	13	2	2

Appendix 5. Summary of ANOSIM outputs testing the influence of socio-demographic factors on the opinions of the fishing community that participated in fisheries surveys during February-March 2011 on Grand Cayman (n = 263).

Demographic	ANOSIM test output	
	R statistic	*P*-value
Gender	0.096	0.075
Age	**0.015**	**0.143**
Nationality	0.063	*0.004
Occupation	**-0.017**	**0.737**
Residency length	**0.029**	**0.144**
Fishing frequency	**0.001**	**0.467**
Fish type targeted	0.011	0.252
Fishing platform	-0.003	0.540

* = significance level <0.05

Appendix 6. Comments by survey respondents expressed during an open-ended question on current management of the marine environment, and that re-occurred during fisheries surveys on the Cayman Islands in February and March 2011.

Island	Re-occurring comments
Grand Cayman	"We need enforcement efforts during the night. 24-hour enforcement" "More enforcement and patrolling are needed" "The number of conch allowed during open season should be reduced" "The size of the marine parks should be increased" "Lobster open season is during spawning times and should be changed" "The marine parks have been left were they are for too long. They need to open up the marine parks and rotate them" "We have a problem with the transient population here. Foreigners on the shore are taking many of the small, undersized fish. That should be regulated better. They could further reduce the minimum size limit" "A license to fish should be introduced for foreigners" "Introduce more stringent limits on the number of fish that can be caught. Make laws species specific" "The tour operators, dive boats and jet skis are having an impact and that should be managed better" "More signs at the boundaries of the MPAs are needed" "Management needs to involve the locals. It starts with education and awareness campaigns to get the fishermen on board" "Litter and pollution are big problems which need to be addressed" "The numbers of fish have really declined since when I was a boy" "They need to protect other species of fish" "Dredging of the North Sound is going to be a major issue" "While the marine parks help with bottom fish, they have no affect on pelagic fish and overfishing comes from long line fishing offshore"

Appendix 6. (*continued*)

Island	Re-occurring comments
Cayman Brac	"Enforcement is inadequate. More marine officers are needed" "The officers are a problem. Enforcement can be inappropriate: There is favoritism for friends/family, they can be over-bearing, and they don't always practice what they preach" "Charges for breaking the marine laws should be stricter" "The laws don't always reflect what is going on out there and are not always appropriate" "Lobster open season coincides with spawning and is at the wrong time of year" "The government does not involve fishermen in management or consult with locals. Decisions are made without involving the local community" "The boats and divers are having a large impact on the marine parks (for example the grouper holes) but all of the management is directed towards fishing" "They have taken away our livelihood and fishing is our heritage" "Grouper fishing should be kept open but a limit should be placed on the number of fish people can catch" "A license to fishing should be introduced for all non-Caymanians" "The marine parks could be extended further" "Some marine parks are in the wrong location" "Management is a good thing. Without the marine parks there would be nothing left" "Closed areas should be rotated around the island and not permanently left in the same place" "Closing the grouper area was a good thing. The numbers of grouper had really declined. Protection should continue" "Spear guns are a problem that needs to be addressed" "The marine parks are working as you can really see a difference in marine life inside and outside of the parks" "Rather than getting foreigners to come over and enforce/monitor the marine parks, locals should be involved"

Appendix 6. (*continued*)

Island	Re-occurring comments
Little Cayman	"More enforcement officers are needed" "Management is not working. Enforcement can be ineffective as favoritism takes place" "The marine parks need to be rotated" "The government should regulate fishing by foreigners, including tourists, through licenses" "A limit on the number of grouper that can be caught should be imposed but do not close the grouper areas again" "The marine parks are geared for divers, not fishermen" "Fishing pressure here is so low it really isn't much of a problem" "Management works really well here. They are doing a good job" "Signage and markers around the marine parks need improving"

Appendix 7. List of the main marine park violations reported by DOE marine fisheries officers.

Marine Park Violation
Taking Conch out of season
Taking Conch above the daily limit
Taking Conch from a Replenishment Zone
Permitting or causing over the daily limit of conch to be loaded on a vessel
Receiving conch over the daily limit
Taking Lobster out of season
Taking Lobster over the daily limit
Taking Lobster under the prescribed size limit
Taking Lobster from a Replenishment Zone
Permitting or causing over the daily limit of lobster to be loaded on a vessel
Taking Whelk out of season
Taking more than the daily limit of Whelk
Taking marine life from shore without a licence
Possession of more than the daily limit of processed Whelk
Taking fish under the prescribed size limit
Possession of an unlicensed spear gun
Taking marine life with an unlicensed spear gun
Taking more than the daily limit with a spear gun
Using a spear gun in a Replenishment Zone
Taking marine life from a Marine Park
Exceeding 5 knots in an Environmental Zone
Taking marine life from an Environmental zone
Anchoring in an Environmental Zone
Damaging coral by anchor
Anchoring a vessel in excess of sixty feet in a marine park
Lifting marine life out of the water in a W.I.Z.
Taking marine life from a W.I.Z
Wearing footwear in a W.I.Z.
Anchoring a boat in water shallower than 3 feet in a W.I.Z.
Taking Turtle during the prescribed closed season
Possession of a turtle without a license
Possession of turtle eggs
Slaughtering a turtle before being inspected by a fisheries officer
Wearing gloves while diving