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A survey of Grenadians on seabird harvest in the Grenada Grenadines

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Abstract Despite their sociocultural and economic value, seabird populations have dramatically declined, in part due to overexploitation. Although seabird harvest is not as common worldwide as it was historically, partly because of protective laws, illegal harvest still occurs, particularly in tropical developing nations. In Grenada, seabird harvest could partly explain the decline of seabird colonies. Our objective was to determine if fishers and recreationists engage in seabird harvest in the Grenada Grenadines and, if so, which sociodemographic factors may be associated with harvesting seabirds. We designed a 64-question survey that we made available at the Fisheries Division office of Sauteurs, Grenada, for 6 weeks each year (15 June to 30 July) from 2015 to 2017. Although respondents claimed that harvesting is a tradition that infrequently occurs today, survey responses and anecdotal evidence suggest seabird harvest still occurs. Continued seabird harvest, combined with other threats (e.g., livestock grazing), could prove detrimental to existing Grenadine seabird colonies. Interestingly, respondents who have collected or eaten seabirds seem unaware of laws that protect seabirds from hunting, which are especially restrictive during the breeding season. Therefore, we recommend establishing a community-based monitoring program that 1) empowers fishers and recreationists through education and awareness of seabird harvest, 2) provides a patrolling presence on islands previously neglected, and 3) ensures continuity of seabird data collection in the Grenada Grenadines.

Keywords egg collection, fishers, Grenada Grenadines, local knowledge, poaching, seabirds, sociodemographic factors

Resumen Encuesta a los granadinos sobre la captura de aves marinas en las Granadinas de Granada • Las poblaciones de aves marinas han disminuido drásticamente, a pesar de su valor económico y sociocultural, y es debido en parte a la sobreexplotación. Aunque su captura no es tan común a nivel global como lo era históricamente, en gran medida por las leyes de protección, todavía ocurre de manera ilegal y sobretodo en las naciones tropicales en desarrollo. En Granada, la captura de aves marinas podría explicar en parte el declive de las colonias de estas especies. Nuestro objetivo fue determinar si los pescadores y aquellos que realizan actividades al aire libre en las Granadinas de Granada participan en la captura de aves marinas y de ser así, qué factores sociodemográficos pueden estar asociados con las mismas. Diseñamos una encuesta de 64 preguntas que estuvo disponible en la oficina de la División de Pesquerías de Sauteurs, Granada, durante 6 semanas cada año (del 15 de junio al 30 de julio) de 2015 a 2017. Aunque los encuestados afirmaron que la captura es una tradición que ocurre hoy en día con poca frecuencia, las respuestas de las encuestas y la evidencia anecdótica sugieren que todavía se produce. La captura continua de aves marinas, en conjunto con otras amenazas (por ejemplo, el pastoreo de ganado), podría ser perjudicial para las colonias de estas especies que existen en las Granadinas. Curiosamente, los encuestados que han recolectado o comido aves marinas parecen desconocer las leyes que protegen a estas especies de la caza y que son especialmente restrictivas durante la temporada reproductiva. Por lo tanto, recomendamos establecer un programa de monitoreo comunitario que 1) capacite a los pescadores y a aquellos que realizan actividades al aire libre en la zona a través de la educación y la concientización sobre la captura de aves marinas, 2) proporcione patrullaje en las islas que han sido descuidadas previamente, y 3) garantice la continuidad de la recopilación de datos de aves marinas en las Granadinas de Granada.

Palabras clave aves marinas, caza furtiva, conocimiento local, factores sociodemográficos, Granadinas de Granada, pescadores, recolección de huevos

Résumé Enquête auprès des Grenadiens sur la chasse aux oiseaux marins dans les Grenadines de la Grenade • Malgré leur valeur socioculturelle et économique, les populations d'oiseaux marins ont subi des déclins importants, en partie dus à leur surexploitation. Bien que la chasse aux oiseaux marins ne soit pas aussi répandue dans le monde qu'autrefois, notamment grâce aux lois de protection, la chasse illégale existe toujours, particulièrement dans les pays tropicaux en développement. À la Grenade, ces pratiques pourraient partiellement expliquer le déclin des colonies d'oiseaux marins. Notre objectif était de déterminer si les pêcheurs et les plaisanciers participent à la chasse aux oiseaux marins sur les îles des Grenadines de la Grenade et, si c'était le cas, quels facteurs sociodémographiques pourraient être associés à ces pratiques. Nous avons conçu un questionnaire de 64 questions que nous avons mis à disposition au

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bureau des pêches de Sauteurs, à la Grenade, chaque année pendant 6 semaines (du 15 juin au 30 juillet) de 2015 à 2017. Bien que les répondants aient affirmé que la chasse aux oiseaux marins constituait une tradition ancienne et était devenue rare de nos jours, certaines de nos observations (p. ex. un seau d'œufs) suggèrent que cette pratique a toujours lieu. La poursuite de la chasse aux oiseaux marins, combinée à d'autres menaces (p. ex. le pâturage du bétail), pourrait s'avérer préjudiciable aux colonies d'oiseaux marins des Grenadines. Il est intéressant de noter que les répondants ayant prélevé ou mangé des oiseaux marins ne semblaient pas connaître les lois qui protègent ces espèces de la chasse et qui sont particulièrement restrictives pendant leur saison de reproduction. Par conséquent, nous recommandons d'établir un programme communautaire de suivi des colonies qui 1) responsabilise les pêcheurs et les plaisanciers à travers l'éducation et la sensibilisation sur la chasse aux oiseaux marins; 2) assure une présence de patrouille sur des îles jusque-là non surveillées; et 3) permette la continuité de la collecte de données sur les oiseaux marins des îles des Grenadines de la Grenade.

Mots-clés braconnage, collecte d'œufs, connaissances locales, facteurs sociodémographiques, Grenadines de la Grenade, oiseaux marins, pêcheurs

Seabirds, a threatened avian group for which extinctions are probable within the next century (Butchart *et al.* 2004, Cuthbert and Sommer 2004, Paleczny *et al.* 2015), are declining globally. These declines can be attributed to a variety of threats, including climate change, introduced terrestrial predators (Spatz *et al.* 2014), human disturbance in nesting colonies, marine plastic pollution, habitat loss and degradation, and overexploitation (Dias *et al.* 2019). Overexploitation of seabirds occurs through incidental bycatch in trawling, gillnet, and longline fisheries (Anderson *et al.* 2011, Žydelis *et al.* 2013), as well as intentional capture for human consumption (Awkerman *et al.* 2006). Although historically occurring worldwide, direct seabird exploitation is now predominantly restricted to developing countries in the tropics (Croxall 1991, Croxall *et al.* 2012).

Throughout history, seabirds have held both sociocultural and economic values for cultures across the globe. Early cultures (e.g., Aleut, Māori, and Moriori) harvested seabirds for sustenance as well as functional purposes, such as making musical instruments and tools from bones, feathers, and other body parts (Warham 1990, Hofman and Hoogland 2003, Coffey and Ollivierre 2019). Early European sailors revered seabirds, believing that some, such as gulls, embodied the souls of drowned sailors (Hole 1967) and that seeing an albatross at sea was a sign of good luck (Wordsworth and Coleridge 1798). Conversely, seabirds could also be seen as bad-weather omens (Hole 1967). Storm petrels, for example, were called "Mother Carey's chickens" and were both revered and feared, including in Grenada. Mother Carey is a legendary character embodying the sea's threats; storm petrels were thought to warn sailors of approaching storms (Wilson 1788, Drayton 1912, Brewer 1995).

Sailors harvested seabirds for food (Loti 1889), tools (e.g., baited hooks; Warham 1990), and fashion (e.g., feathers for headdresses and webbed feet for tobacco pouches; Hole 1967, Tickell 2000). Many believe that such overexploitation caused the extinction of the Great Auk (*Pinguinus impennis*; Bengston 1984). By the 1890s, seabirds had also become popular in the millinery trade, for which they were commercially harvested and sold in luxury markets in North America and Europe (Haynes 1987, Spennemann 1998).

Today, international laws and agreements—such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973), the Convention on the Conservation of Antarctic Marine Living Resources (1980), and the Agreement on the Conservation of Albatrosses and Petrels (2001)—act to reduce colony harvest and incidental catches within fisheries (Trouwborst 2008). Similarly, national laws have been put in place in many countries, including the Sea Birds Preservation Act (1869, United Kingdom), the Migratory Bird Treaty Act (1918, United States), and the Wild Birds Protection Act (1919, Guyana). However, these laws are not always observed or enforced (e.g., in the Caribbean; Devenish *et al.* 2009).

Seabird harvesting remains important for culture, income, or food security in many economically challenged communities around the world (Le Corre and Bemanaja 2009, Naves 2018). Native communities in Alaska legally rely on several species of seabirds and their eggs for food (Young *et al.* 2014, Naves 2018), whereas other populations target a single species (Awkerman *et al.* 2006, Chen *et al.* 2015). The Māori of New Zealand, for example, have traditionally harvested the Gray-faced Petrel (*Pterodroma gouldi*), although they have recently incorporated sustainable harvest measures in cooperation with local scientific research groups (Lyver *et al.* 2008).

In some subtropical and tropical areas, fishers harvest tern eggs for the local seabird egg trade (Chen *et al.* 2015, Mondreti *et al.* 2018). During any given harvest on Pitti Island, India, fishers illegally take up to 45% of the available Sooty Tern (*Onychoprion fuscatus*) eggs; the number of terns in general on the island declined by 95% between 1963 and 2014 (Mondreti *et al.* 2018). Eggs of Sooty Terns and other seabirds have been an important food source for local people both historically (Bradley and Norton 2009) and recently (Feare 1978, Cline *et al.* 1979, Burger and Gochfeld 1994, Gochfeld *et al.* 1994), especially in countries with a high poverty level (van Halewyn and Norton 1984, Burger and Gochfeld 1994). In addition to being a source of protein, eggs and chicks are considered a delicacy in some countries (Gochfeld *et al.* 1994). Seabirds have also been harvested for their guano, bones (Frank and Benson 1998), and aphrodisiac properties (Gochfeld *et al.* 1994, Chardine *et al.* 2000).

In many Caribbean and other tropical nations, seabird harvest is a deeply rooted sociocultural tradition (van Halewyn and Norton 1984). However, seabird colonies have been declining in the Caribbean, including in Grenada (Schreiber and Lee 2000, Lowrie

et al. 2012). Reviews of the literature have identified seabird harvest as the most important threat to and cause of past declines of seabirds in the Caribbean region (van Halewyn and Norton 1984, Burger and Gochfeld 1994). Other factors could explain current declines, but seabird harvest may still be at least partially responsible in some areas (Schreiber and Lee 2000). A 2013 survey of colonies in the transboundary Grenadines revealed evidence of seabird harvest (including piles of seabird carcasses and buckets of seabird eggs), potentially by artisanal fishers who are thought to switch to seabirds and their eggs when the fishing season is closed or unproductive (SusGren 2014). People visiting the Grenadine islands for recreational goat hunting also occasionally collect eggs opportunistically (J. Coffey pers. comm.).

Seabird harvest is illegal in Grenada according to the Birds and Other Wildlife (Protection) Act of 1957 (Government of Grenada 1957), but Lowrie *et al.* (2012) suggest that the practice still occurs in the Grenadines and is due in part to a lack of enforcement. Forestry Department officials on Grenada and Carriacou indicate that existing legislation on seabird poaching has not been applied in Grenada as of 2019 (J. Coffey pers. comm.). In the Grenadines, the extent of seabird harvest and its impact on seabird colonies have not been quantified, nor have the cultural and sociodemographic reasons for harvesting seabirds been identified.

Our objective was to determine if fishers and recreationists continue to engage in seabird harvest in the Grenada Grenadines and, if so, which sociodemographic factors (e.g., education, occupation, or age) are associated with the harvest. To address this objective, we designed a survey targeting artisanal fishers and recreationists in Sauteurs, a small community of ~1,300 people on the north coast of mainland Grenada (World Population Review 2020). Some locals commute to and from nearby Grenadine islands, where they temporarily set up camps (e.g., on the uninhabited islets of Les Tantes and Sandy Island) or permanently reside in small communities (e.g., on Isle de Ronde). These islands support globally and regionally significant seabird colonies and other wildlife year-round.

Methods

Data Collection

We designed a survey that included 64 questions (see Supplement) about respondents' 1) sociodemographic characteristics, 2) interaction with seabirds, and 3) knowledge about seabird distribution. We originally used a 50-question survey in 2015 and 2016, but revised it to remove 2, add 16, and rephrase 4 questions before the 2017 data collection period (see Supplement). We made our survey available at the Fisheries Division office in Sauteurs, Grenada, for 6 weeks each year (15 June to 30 July). We selected the Fisheries Division office because of its proximity to the seaport from which most fishers and recreationists leave and enter the Grenada mainland. Since Sauteurs is a small community, we recruited participants mostly through a snowball sampling method (Goodman 1961). Before taking the survey, participants signed consent forms with the understanding that participation was voluntary and responses were confidential. Consenting participants could complete the paper questionnaire in the privacy of their homes or at the Fisheries Division office. This protocol was approved by the Arkansas State University Institutional Review Board [750611–2].

Data Analyses

Of the 64 questions in our survey, 19 questions received so few (4–11) responses that we did not summarize or report them in this study (see Supplement for the full survey). We used descriptive statistics to qualitatively analyze 32 questions about where respondents live and fish, their harvesting habits (i.e., frequency, season, location, number of collected seabirds or eggs, and target species), the importance of and reason for harvesting, their interactions with or knowledge of (other) seabird harvesters, and their experience selling their harvest (Table 1).

We used the remaining 13 questions for a quantitative analysis that related sociodemographic factors to seabird harvest (Table 1). However, some respondents provided inconsistent responses. For example, some respondents who said they had eaten seabirds or their eggs answered "no" to questions about harvesting seabirds or their eggs, yet indicated the year of their last harvest. To avoid discarding contradictory data, we therefore defined "seabird harvest" to include both direct (if respondents reported collecting seabirds or their eggs) and indirect (if respondents reported eating seabirds or their eggs) contributions. We then pooled responses from eight questions about past and current experience collecting and eating seabird adults, chicks, or eggs to create a single binary response variable: "contributed to seabird harvest" versus "did not contribute to seabird harvest" (Table 1). To determine which sociodemographic factors drive fishers and recreationists to contribute to seabird harvest in the Grenada Grenadines, we considered the following explanatory variables: 1) current occupation (for which we combined responses on primary and secondary occupations into a single binary variable: "worked in fisheries" versus "did not work in fisheries"), 2) age class (18–35, ≥ 36 yr old), 3) household size (1–2, ≥ 3), and 4) knowledge of any laws against seabird harvest (yes, no, unsure). Because we combined two questions in determining current occupation, these four explanatory variables were based on a total of five questions (Table 1). Because of our small sample size, we used Fisher's exact tests to analyze the effect of our four explanatory variables on seabird harvest, using program R (R Core Team 2018).

Results

A total of 32 respondents participated in the survey during the 3-yr study period. Only 6 questions were answered by all respondents, and 14 questions received 30 or more responses.

Of the four sociodemographic factors, only the knowledge of laws was significantly associated with contribution to seabird harvest (p = 0.036; Table 2). Respondents who either did not know if laws existed or believed that there were no laws protecting seabirds were more likely to report contributing to seabird harvest. People who contributed to seabird harvest directly or indirectly tended to be over the age of 35 (p = 0.062). Their occupation and the size of their household were not related to the contribution to seabird harvest (Table 2).

All 32 respondents reported living ≤ 5 km from Sauteurs and 84% identified fishing as a primary or secondary occupation. Of respondents who reported fishing as an occupation (n = 27), 14 (52%) targeted the waters of Isle de Ronde and Sauteurs Bay, and 6 (22%) targeted the waters near Sandy Island and Les Tantes. In addition, respondents identified Sandy Island, Les

Table 1. Summary of a 64-question survey administered in 2015–2017 to fishers and recreationists going through the Fisheries Division Office of Sauteurs, Grenada. Questions 18–25 were pooled to form a single binary response variable "contributed to seabird harvest" versus "did not contribute to seabird harvest," and questions 7–8 were combined to form a single binary explanatory variable "worked in fisheries" versus "did not work in fisheries." Of the 64 questions, 19 generated few (4–11) responses and are not included below. See Supplement for full survey.

Survey questions		Variable	Qualitative Analysis	Quantitative Analysis
1	Where do you live?	Residency	X	
2	Where do you mostly fish?	Fishing location	X	
3	What is your age?	Age (18–35, ≥ 36)		X
7	What is your primary occupation?	Occupation (fisheries, no fisheries)		X
8	What is your secondary occupation?	Occupation (fisheries, no fisheries)		*X*
10	How many people live in your household?	Household size (1–2, ≥ 3)		X
18, 20	Have you ever eaten seabirds/seabird eggs?	Contribution to seabird harvest (yes, no)		X
19, 21	Do you currently eat seabirds/seabird eggs?	Contribution to seabird harvest (yes, no)		X
22	Have you ever collected seabirds (adults or chicks) or their eggs?	Contribution to seabird harvest (yes, no)		X
23–25	In what year have you last harvested seabird adults/chicks/eggs?	Contribution to seabird harvest (yes, no)		X
28–30	How important is harvesting seabird adults/chicks/eggs to make a living?	Importance of seabird harvest to make a living (not, somewhat, very)	X	
31–33	Which period is better for harvesting seabird adults/chicks/eggs?	Best period for seabird harvest (Jan–Mar, Apr–Jun, Jul–Sep, Oct–Dec, unsure)	X	
34–36	How many seabird adults/chicks/eggs would you estimate you collect per year?	Number of seabirds collected (0, 1–9, 10–50, 51–100, > 100)	X	
37–38	How many times a year do you normally harvest seabird adults/chicks?	Annual frequency of seabird harvest (0, 1–4, 5–10, > 10)	X	
39–41	Which islands are best for harvesting seabird adults/chicks/eggs?	Best island for seabird harvest	X	
42	Is most seabird and egg harvesting done by residents or outsiders?	Harvesters (residents, outsiders, unsure)	X	
43–44	Do you know about anyone who currently harvests seabird adults/chicks/eggs?	Knowledge of others that harvest seabirds (yes, no, prefer not to answer)	X	
47–48	Why do you think people harvest seabird/eggs?	Reason for harvesting seabirds (income, food, prestige/tradition, other)	X	
50	How do you know when the eggs are good to eat?	Egg harvest knowledge	X	

Table 1. cont.

Survey questions		Variable	Qualitative Analysis	Quantitative Analysis
51	Is harvesting seabirds or their eggs a tradition or part of Grenadines' culture?	Tradition (yes, no, unsure)	X	
52	Are there conflicts over who gets to harvest a certain island?	Conflicts (yes, no, unsure)	X	
55	Are there any laws regarding collecting seabirds or eggs?	Knowledge of a law against seabird harvest (yes, no, unsure)		X
57	Regarding seabirds, do you think people are collecting… than in past years?	Seabird harvest trend (more, the same, less, unsure)	X	
58	Which seabirds are your most important harvest species?	Target seabird species for harvest	X	
59	Do you sell seabirds (adults, chicks, or eggs)?	Seabird trade (yes, no)	X	
60–62	What is the average cost per adult bird/chick/egg?	Average cost per seabird (< $3, $3–5, other)	X	
63	Where do you sell seabirds (adults, chicks, or eggs)?	Market location (Bayside, Market area, other)	X	
64	To whom do you sell seabirds?	Customers (locals, tourists, other)	X	

Table 2. Fisher's exact tests (α = 0.05) for potential sociodemographic factors driving seabird harvest in Grenada, using responses (n = 32) collected in 2015–2017.

Factor	*p*-value	Categories	Number of Respondents	Number of Respondents Who Contributed to Seabird Harvest
Occupation	0.637	Fishing	27	10 (37%)
		Non-fishing	5	1 (20%)
Age	0.062	18 to 35	15	8 (53%)
		≥ 36	17	3 (18%)
Household size	0.139	1 to 2	12	2 (17%)
		≥ 3	20	9 (45%)
Knowledge of laws	0.036	Yes	6	0 (0%)
		No	12	3 (25%)
		Unsure	14	8 (57%)

Tantes, Lee Rocks, and Diamond Rock as islands used for seabird harvest, with Diamond Rock ranking as the best island for harvesting seabirds (Fig. 1).

Of all 32 respondents, 72% reported that the most harvested genus was boobies (*Sula*); as one respondent noted, "they have the most meat and are always present." Respondents also reported harvesting pelicans (9% of respondents), gulls (3% of respondents; one noted that gulls are "easy to catch"), and terns (3% of respondents). Of 19 respondents who answered a question about how to tell when eggs are good to eat, most said that eggs

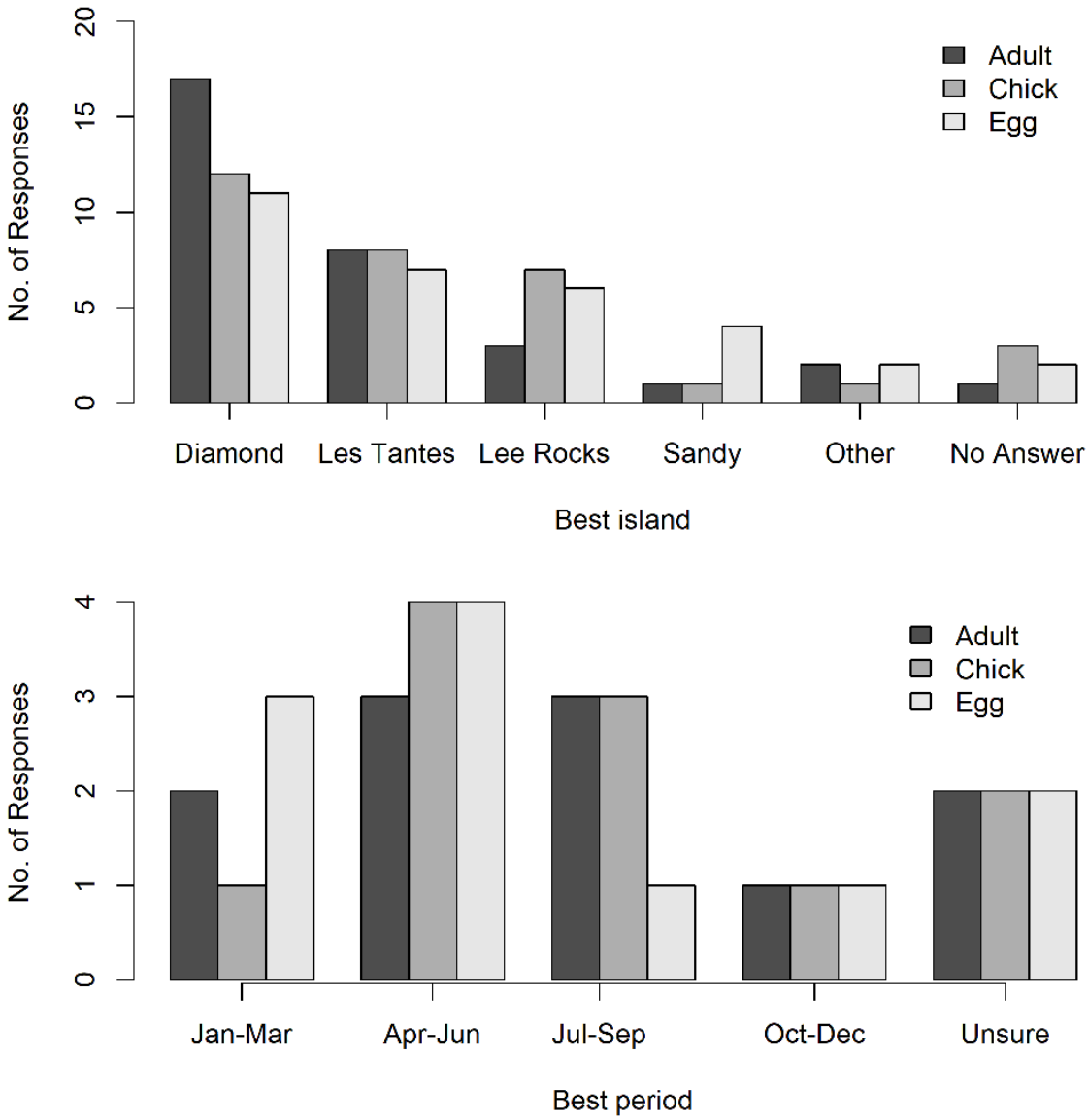

Fig. 1. Best island (*n* = 32 responses) and period (*n* = 11 responses) to harvest seabird adults, chicks, and eggs in the Grenada Grenadines, based on responses from surveys distributed in the community of Sauteurs, Grenada, from 2015 to 2017. The lower graph includes only responses from respondents who contributed to seabird harvest by eating or collecting seabirds or their eggs.

are edible when they sink in a water-filled container (*n* = 8, 42%) or do not have a dark-brown color (*n* = 7, 37%); others recommended shaking eggs to check that they are not hollow (*n* = 2, 11%) or provided an unclear explanation (*n* = 2, 11%).

Of the 32 respondents, 11 contributed to the harvest of seabirds, their chicks, or their eggs. Contributors were asked in which years they had harvested; the 10 contributors who answered this question reported having last harvested between 1997 and 2016. All 11 contributors to seabird harvest answered a question about the best period for harvest; 9 specified a period, with most indicating April–June, and 2 reported that they were unsure (Fig. 1). Of the 11 contributors to seabird harvest, 4 people harvested 1–5 times per year to collect up to 50 seabirds or their eggs, and 3 reported collecting over 100 individuals or their eggs per year. Surprisingly, of the latter 3 respondents, 1 person did not consider seabird harvest important to making a living, despite making trips more than 10 times per year (Fig. 2). Two of the contributors to harvest reported selling seabirds to the Sauteurs community at 1–2 USD (3–5 Eastern Caribbean dollars) per chick or egg, but had not done so in recent years.

Notably, only 1 person out of 11 contributors to harvest considered seabird harvest important to making a living. In contrast, seabird harvest is regarded as a tradition by 13 of the 30 respondents who answered the question, including 6 of the 10 contributors to harvest who answered. This practice, however, is thought to have become less common by 22 of the 31 people who answered the question, including 10 of the 11 contributors to harvest. Many respondents believe that seabirds are harvested by Sauteurs residents more than by non-residents (16 of 29 people who answered, including 8 of 10 contributors to harvest who answered), and most respondents said there are no conflicts over who gets to harvest at which island (25 of 29

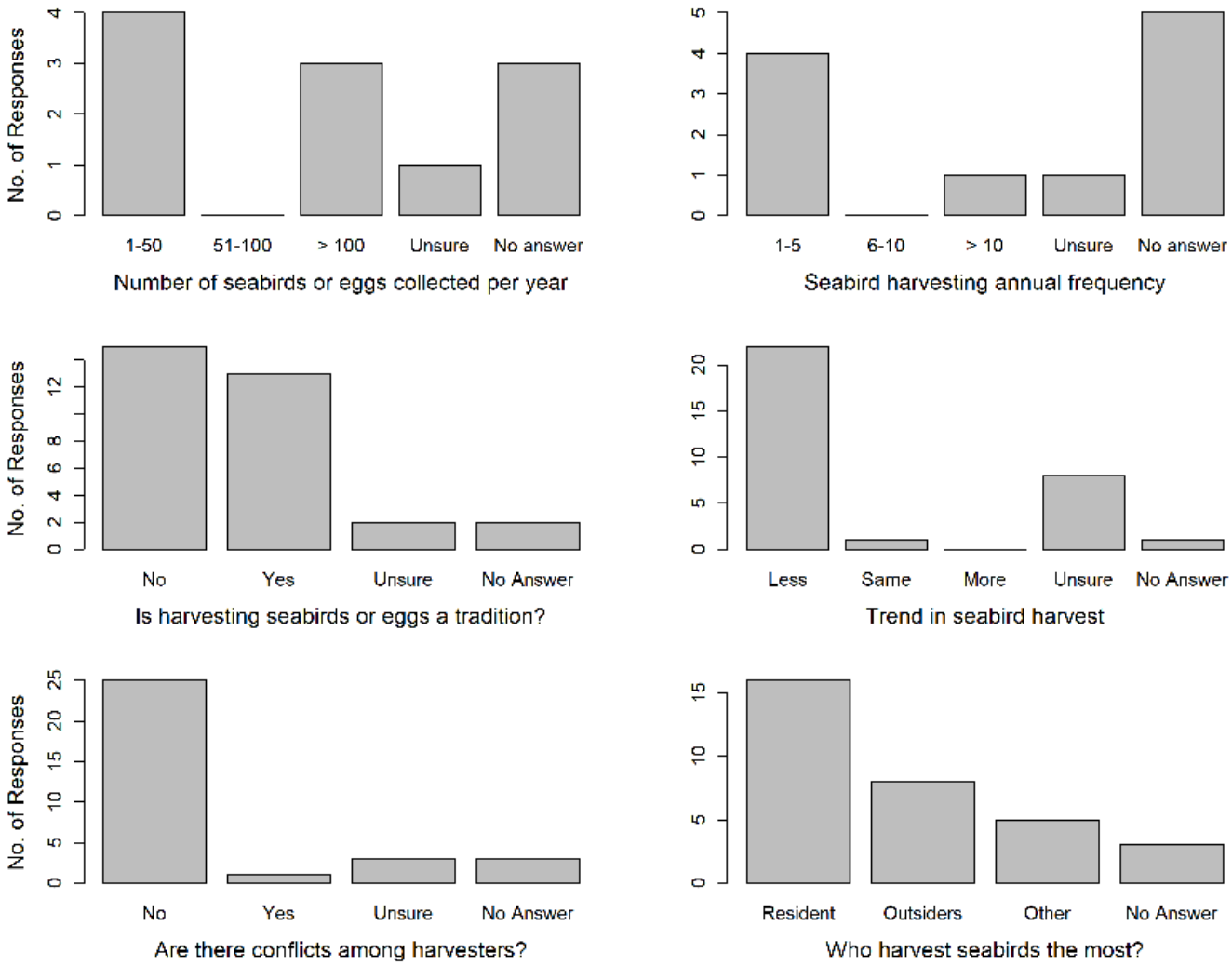

Fig. 2. Responses (upper two graphs: *n* = 11; lower four graphs: *n* = 32) to six seabird harvest questions from surveys distributed in the community of Sauteurs, Grenada, from 2015 to 2017. The top two graphs include only responses from respondents who contributed to seabird harvest by eating or collecting seabirds or their eggs.

people who answered, including all 10 contributors to harvest who answered) (Fig. 2). Most of the 32 respondents, including all 11 contributors to seabird harvest, were either unaware of any rules regarding seabird harvest (*n* = 12) or unclear about the laws (*n* = 14), but 6 individuals knew there was a law regarding the collection of seabirds or their eggs (Table 2). Finally, of the 4 respondents who answered questions about why seabird and egg harvest occurs, all 4 believed that seabirds were harvested as a supplementary food source, yet none of the 4 reported knowing anyone who still harvests seabirds. Of the 32 respondents, 65% believe that people harvest less than before, including 5 who reported increasing gas prices as the main reason. One respondent attributed the decline in seabird harvest to people hunting goats instead of seabirds.

Discussion

Caribbean seabird populations remain in decline (Schreiber and Lee 2000), including in the Grenada Grenadines (Lowrie *et al.* 2012). In 2014, an Isle de Ronde resident shared his memory of much larger bird colonies on the Grenada Grenadines: "We used to look on shore from boat and you could not see anyone. The everything white, full of birds" (WAS pers. obs.). Seabird harvest is suspected as a major cause of this decline (Lowrie *et al.* 2012). Therefore, our objective was to determine which sociodemographic factors (education, occupation, age, etc.) were associated with fishers and recreationists harvesting seabirds in the Grenada Grenadines.

Grenada's workforce (i.e., members of the population aged ≥ 15 yr) represents 51% of the total population (United Nations 2018); 76% of the workforce is employed (CIA 2020), including 11% in the industry sector (which accounts for fisheries, forestry, and agriculture; Grenada Central Statistics Office and World Bank 2015). Demographic data are not available for Sauteurs, but assuming the general economy and labor of this ~1,300-person community (World Population Review 2020) are comparable to the nation as a whole, our sample size represented 2.5% of the community (*n* = 32 total responses), 6% of the employed workforce (*n* = 30 responses from employed respondents), and 41% of the industry labor of Sauteurs (23 responses from respondents employed in farming or fisheries). Because Sau-

teurs is the closest port to the northern fishing zone of Grenada, our exploratory study provides some valuable information about the occurrence of and reason for seabird harvest in the Grenada Grenadines.

Since it is an illegal activity, the extent of seabird harvest was likely underreported. This presumably affected our results. Even so, survey responses and other evidence show that seabird harvest is occurring at levels that potentially have a substantial negative impact on seabird colonies. Three respondents reported having harvested over 100 seabirds (adults, chicks, or eggs) in a single year. In 2015, an anonymous source sent us a photograph of a bucket that contained over 30 Laughing Gull (*Leucophaeus atricilla*) eggs; the accompanying email noted that they had been collected in a single trip to Sandy Island (Fig. 3; WAS pers. obs.). These numbers are substantial, especially considering that most seabird species on these islands lay only 1–2 eggs, from which a single chick fledges every year, and that some species have delayed maturity (Schreiber and Burger 2002). Moreover, seabird harvest is a source of human disturbance, which can cause nesting seabirds to temporarily or permanently abandon their nests. Eggs and chicks can subsequently perish from heat stress or predation (Anderson and Keith 1980, Safina and Burger 1983).

Laughing Gull eggs seem to be important for seabird harvest, as illustrated by the bucket of eggs (Fig. 3). This species is the second most abundant seabird in the Grenada Grenadines, after the Red-footed Booby (*Sula sula*; Lowrie *et al.* 2012), and Sandy Island, which ranked highly as a harvest location (Fig. 1), is predominantly occupied by Laughing Gulls. This island is also one of the most easily accessible and closest to mainland Grenada. However, although respondents in Coffey and Ollivierre's (2019) study rated Laughing Gulls as "important" for their eggs, they ranked Brown Boobies (*Sula leucogaster*) even higher, considering them "highly important" for their chicks and eggs. In our own study, respondents identified Brown Boobies as the primary target of harvest. We also observed anecdotal evidence of Brown Booby harvest in 2017, when a water taxi passenger admitted that he intended to hunt Brown Boobies with some friends later that day. He said, "I am afraid of the birds. I never did it before, but the others supposed to teach me how to trap it" (WAS pers. obs.). Brown Boobies are especially vulnerable to harvest and population declines for several reasons. They are a consistent food source for harvesters because they are year-round residents of the Grenadine islands. Furthermore, their nesting cycle takes up to 35 weeks to complete and they nest on the ground in accessible places (Schreiber and Norton 2020), unlike the tree-nesting Red-footed Boobies (Schreiber *et al.* 1996). Finally, they raise only one young per year and do not reach maturity until 2–4 yr after fledging (Schreiber and Norton 2020).

Fig. 3. Anecdotal evidence of seabird harvest in the Grenada Grenadines: a photo of a bucket full of Laughing Gull eggs received electronically from an anonymous source in 2015. The photograph was taken on Sandy Island a week before we received it.

Based on the responses received, seabird harvest is more important as a tradition than an economic activity, though some respondents have sold seabirds or their eggs. Currently, fuel prices could be a deterrent for seabird harvest; the consumer price index for energy consumption, including gas and other fuels, increased by about 138% from 2001 to 2014 (Grenada Central Statistics Office 2014), and five respondents cited increasing gas prices as the main cause for less seabird harvest.

Some communities in the Caribbean subsist partially on seabird eggs and chicks (Burger and Gochfeld 1994), and some residents of Sauteurs may be similarly reliant on seabird harvest as a supplemental food source. Given that poverty can lead to poaching (Kuhl *et al.* 2009), whether for financial gain or as a personal food source (Skonhoft and Solstad 1998), the fact that artisanal fishing is likely not a large source of income and the unemployment rate is high (24% in 2017; CIA 2020) could partially explain the occurrence of seabird harvest in Grenada. In addition, seabird meat is considered an aphrodisiac (Chardine *et al.* 2000, van Vliet *et al.* 2017, Coffey and Ollivierre 2019), which may add to the value of seabird harvest (Gochfeld *et al.* 1994).

On Grenada, about 40 official acts protect biodiversity. These include the Birds and Other Wildlife (Protection) Act of 1957, which specifically addresses seabirds (Government of Grenada 2000). This act, last amended in 1990, states: "Any person who kills, wounds or takes any wild bird or the eggs or nest of any wild bird specified in the First Schedule, or who has in his or her possession any such bird killed, wounded or taken, or any part thereof, or the eggs or nest of any such bird, shall be guilty of an offence" (Government of Grenada 1957: section 3). The act further stipulates that "every person guilty of an offence shall be liable to a fine of one thousand dollars and to imprisonment for six months" (Government of Grenada 1957: section 11). Wild birds specified in the First Schedule include all seabirds (Government of Grenada 1957). A lack of knowledge about conservation laws can lead to illegal harvest (Skonhoft and Solstad 1998), and according to our survey, everyone who contributed to seabird harvest was unaware of any laws relevant to seabird protection. Enforcing existing laws would raise awareness of the illegality of seabird harvest, but enforcement can be difficult because of the limited resources (e.g., financial, human, and infrastructure) available to Small Island Developing States (SIDS) such as Grenada (Potter 1993, Fisher and Christopher 2007).

However, community members may also feel empowered and change their behavior in response to learning about current environmental issues and experiencing direct benefits of conservation. Community-based programs that involve seabird

colony monitoring (EPIC 2018) or ecotourism (Scheyvens 1999) support conservation and can increase the inflow of revenue to the area. Programs that involve economic benefit may meet with success (Nilsson *et al.* 2016); tourism-based possibilities include a government tax on recreational equipment (Cline *et al.* 1979), or distributing revenue generated from ecotourism (e.g., snorkeling, sailing, or seabird sighting from the sea) among guides and patrollers. However, tourism on Grenada is not yet well developed, and such initiatives are therefore currently unlikely to generate much revenue. Also, tourism can be detrimental if not strictly regulated (Burger and Gochfeld 1994, Bradley and Norton 2009), so careful regulations would need to be established if such tourist-based programs are developed in Grenada. Moreover, community members do not always favor monetary incentives (Galvin *et al.* 2018), and such an approach may not completely eliminate seabird harvest. A different approach that may be more successful is to give communities control over their natural resources (Lyver *et al.* 2008, Galvin *et al.* 2018, Williams *et al.* 2019). With an increased sense of ownership, community members use their resources more sustainably out of self-interest (Nilsson *et al.* 2016). We therefore support Coffey and Ollivierre's (2019) recommendation to engage volunteers to promote stewardship for natural resources, train local bird guides, and educate tourists about the region's natural history. We also specifically recommend training local fishers to monitor seabird nests and patrol for illegal activity. If residents of Sauteurs represent most of the people who directly harvest seabirds in the Grenada Grenadines, such a program could be particularly effective in reducing poaching and preventing overexploitation. In addition to gaining new skills and knowledge, as well as empowerment and positive status in the community, local fishers may subsequently experience increased fishing success, because healthier seabird colonies help fishers find schools of fish (Marcovaldi and Marcovaldi 1999, Nilsson *et al.* 2016, Galvin *et al.* 2018).

In conclusion, poverty and the lack of knowledge of local conservation laws may be associated with direct or indirect seabird harvest in the Grenada Grenadines. A solution to mitigate illegal seabird harvest could be to implement a community-based nest-monitoring program to help the conservation of seabirds and directly benefit the community of Sauteurs. If successful, this program would further help collect nesting data that could be used to monitor colony trends, refine conservation actions, and influence policy.

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Title Page Illustration

Brown Booby (*Sula leucogaster*) adult and chick; photo taken on Diamond Rock, Grenada, on 26 May 2017 by Wayne A. Smart.

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