

Cruzan Fishers' Perceptions of the Socio-economic and Biological Performances of Marine Closures in St. Croix

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ABSTRACT

Despite the growing use of marine protected areas and seasonal closures to promote the sustainable use of marine ecosystems, few studies have examined their socio-economic performance. This study details commercial fishermen's views regarding the biological and socioeconomic performance of the expansion of the Buck Island Reef National Monument (BIRNM) and the red hind seasonal closure off St. Croix, U.S. Virgin Islands. The analysis, which drew on 95 in-person closed-ended surveys and 14 semi-structured interviews, showed that fishermen believed that the expansion enhanced fish production within the monument, but they were irresolute about its ability to protect spawning aggregations, replenish fish abundance outside its boundaries, and protect fish sensitive sites. Fishermen also reported that the expansion marginalized their livelihoods and the well-being of their local communities since access to productive lobster and conch grounds and a popular fish-aggregating device was curtailed. The perceived conservation benefits of the red hind seasonal closure were more tenuous but broadly mirrored those voiced for the BIRNM. Finally, fishermen stated that the mounting number of closures and gear restrictions has brought about severe economic hardships and has made them more reliant on the southern grounds, which are exposed to industrial and waste treatment effluent. This study underscores the need to closely monitor and assess the biological and socio-economic performance of closures in light of the underlying uncertainty of marine ecosystems and unintended consequences of social dynamics.

KEY WORDS: Buck Island, red hind closure, socio-economic

RESUMEN

A pesar del creciente uso de áreas protegidas marinas y vedas estacionales para promover el uso sustentable de ecosistemas marinos, pocos estudios han examinado su desempeño socioeconómico. Una gestión eficaz del cierre de áreas marinas, necesita del apoyo y estrecha colaboración de los administradores de recursos, así como de las diversas partes interesadas, incluyendo los pescadores. El objetivo de este estudio es asistir a los administradores y los tomadores de decisiones maximizar ese apoyo, proporcionándoles un claro entendimiento de las percepciones de los pescadores sobre los cierres marinos. El estudio describe las percepciones de pescadores comerciales sobre el desempeño biológico y socioeconómico de la reciente expansión del Monumento Nacional de Buck Island Reef (BIRNM, por sus siglas en inglés) y de la veda estacional para el mero pinto (o cabrilla) en Santa Cruz, Islas Vírgenes Americanas. El análisis que se valió de 95 encuestas personales y 14 entrevistas semi-estructuradas, señaló que los pescadores creen que la expansión incremento la abundancia de peces dentro de sus límites, pero estaban indecisos sobre su efectividad para proteger las agregaciones de desove, incrementar la abundancia de peces en áreas aledañas y proteger sitios críticos para peces. Los pescadores también reportaron que la expansión comprometió su sustento y el bienestar de las comunidades locales puesto que se perdió el acceso a caladeros productivos de langosta y cartucho, y a un popular artefacto atrayente de peces. Los beneficios de conservación percibidos para la veda estacional del mero pinto fueron más tenues, pero fueron semejantes a los expresados para el BIRNM. En último lugar, los pescadores mencionaron que el renovado aumento de cierres y restricciones sobre las artes de pesca, han traído serias dificultades económicas, haciéndolos dependientes de los caladeros del sur de la isla, los cuales están expuestos a efluentes industriales y aguas de residuo.

PALABRAS CLAVES: Monumento Nacional de Buck Island, mero pinto, socioeconómico

INTRODUCTION

Coral reef fisheries are under enormous stress requiring novel approaches to ensure their sustainability. High exploitation rates have not only depleted fish populations but have also threatened the function, productivity and resilience of coral ecosystems (Agardy *et al.* 2003, NRC 2001). The use of marine protected areas has been advanced as a valuable instrument for protecting coral reef fisheries and ecosystems and furthering ecosystem-based management [Jones 2007, NRC 2001]. Seasonal closures have been also suggested as useful in protecting reef fish species, particularly those that have highly aggregated spawning events.

Marine protected areas have a variety of biological and socio-economic goals. Biological goals include protecting depleted, threatened or endangered species, enhancing fish abundance, protecting and preserving habitats, sustaining

biodiversity, replenishing fish stocks or abundance in surrounding areas, hedging against stock collapse and management mishaps, and providing for a natural baseline to improve scientific knowledge and provide educational opportunities (Christie *et al.* 2002, Christie 2005, NRC 2001). In addition, spatial closures may satisfy various societal goals including generating ecotourism, preserving cultural heritage, creating economic and employment opportunities and empowering coastal communities (Christie *et al.* 2002, Christie *et al.* 2002, Christie 2005, NRC 2001, White *et al.* 2002). Despite the growing literature of the biological performance of closures, the empirical social science literature remains sparse (Allen *et al.* 2006, Agardy *et al.* 2003, Christie *et al.* 2002, Christie *et al.* 2002, Oracion *et al.* 2005, Polinac *et al.* 2001, Sholz, *et al.* 2004, White *et al.* 2002). The limited amount of social science research is unfortunate because it has

restricted managers from considering possible socioeconomic conflicts brought on by the closures. Such conflicts may have a destabilizing effect on the effectiveness of marine closures (Christie *et al.* 2002, Christie 2005, Oracion *et al.* 2005).

This study examines small-scale fishermen's perceptions regarding the biological and socioeconomic performance of two recently implemented closures off the island of St. Croix, U.S. Virgin Islands. St. Croix has about 220 small-scale fishermen who use a variety of gears to target lobster, conch, reef-fish and pelagic resources. The Buck Island Reef National Monument (BIRNM), which was expanded in 2001, and the red hind seasonal closure on Lang Bank were selected as case studies because of their historical importance as traditional fishing grounds and the magnitude of the closures, which significantly reduced the amount of available fishable shelf area [Agar *et al.* 2008, Tobias 2004).

Characterization of the Study Areas

Buck Island Reef National Monument — The BIRNM is located about 1.5 miles north of the eastern side of the island of St. Croix, U.S. Virgin Islands (Pitmann *et al.* 2008, Figure 1]. The monument, which is under the jurisdiction of the National Park Service, encompasses a small, uninhabited island surrounded by a mosaic of coral reefs, seagrasses and sand patches (Pitmann *et al.* 2008).

In addition to the impressive coral reefs, BIRNM is home to a vast number of threatened and endangered animal and plant species, including humpback whales, pilot whales, four species of dolphins, brown pelicans, least terns, and the hawksbill, leatherback, and green sea turtles. In 1961, President John F. Kennedy declared it the first U.S. underwater national monument. The goal of the monument was to preserve the island and one of the finest marine gardens in the Caribbean. The original 880 acre monument consisted of a 176 acre island, 259 acre no-take marine garden area and a 445 acre restricted fishing area. On January 17, 2001 President William J. Clinton greatly expanded the Monument to 19,015 acres, protecting 7.4% of the St. Croix shelf area (Pitmann *et al.* 2008). Although, the Clinton Presidential proclamation made the entire monument a no-take area, illegal fishing may still take place in the deeper parts of the monument (Pitmann *et al.* 2008). Active surveillance by law enforcement patrols since 2003 have helped improve compliance (Pitmann *et al.* 2008).

Red hind Seasonal Closure of Lang Bank — Following the collapse of the Nassau grouper stocks in the late 1970s, fishermen began targeting smaller, less frequently marketed groupers such as red hind, coney and graysby, which then became important commercial species (Cummings *et al.* 1997, Nemeth *et al.* 2006). Concerned over the poor condition of the resource, the Caribbean Fishery Management Council (CFMC) established a seasonal closure for

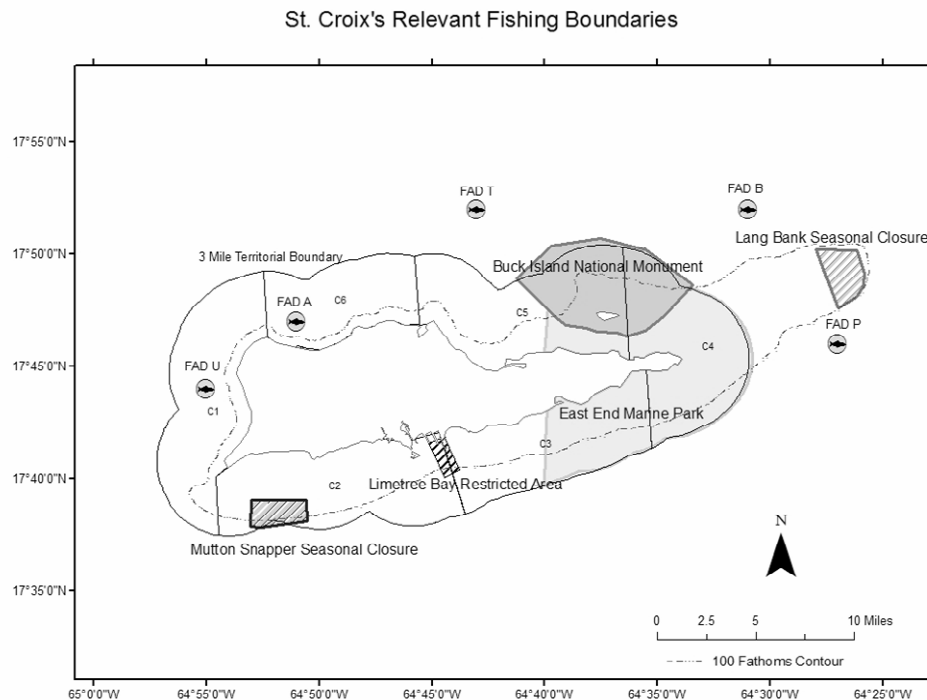


Figure 1. Main marine protected areas and seasonal closures in St. Croix, U.S. Virgin Islands.

the protection of red hind spawning aggregations. On December 1, 1993 Amendment No. 2 of the Reef Fish Fisheries Management Plan (FMP) closed the eastern end of Lang Bank to fishing between December 1 and the last day February (Cummings *et al.* 1997). On February 28, 1995, the CFMC prohibited the use of all bottom tending gear (i.e., pots, traps, bottom longlines, gillnets and trammel nets) year-round.

METHODOLOGY

Two data collections to assess commercial fishermen's beliefs about the effectiveness of the BIRNM expansion and the red hind seasonal closure were undertaken. In the summer of 2005, 95 in-person closed-ended interviews elicited information on fishermen's household and livelihood characteristics, fishing practices, opinions about the state of local fisheries, mangroves and coral reefs, and the performance of local marine closures. Likert scale questions (i.e., 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree) were used to investigate whether the closures protected spawning aggregations, enhanced fish abundance inside and outside the closed areas, protected fish sensitive areas, and to maintained or enhanced the habitat quality¹. Likert scale questions were also used to probe whether the closures impacted fishermen's ability to support themselves and their families and generated economic hardships to the local fishing community, and whether they created employment opportunities. The original intent was to sample 80 randomly selected fishermen drawing from the 2003 U.S. Virgin Islands' commercial fishermen census database (Kojis 2004); however, time constraints resulted in a randomly selected sample of 61 fishermen and an opportunistic sample of 34 fishermen. Chi-squared (χ^2) tests of independence on the biological and socio-economic attitudinal questions showed that there were no statistical differences between the random and non-random samples; thus, both samples were pooled. The pooled sample accounted for about 43% of the commercially licensed population of fishermen in St. Croix.

In the spring of 2008, a follow-up data collection using snowballing sampling techniques was undertaken to contextualize the findings of the previous survey. In total, 14 interviews were conducted. Local fishermen representatives and fisheries officers of the U.S. Virgin Island's Division of Fish and Wildlife served as liaisons to the fishing community. In addition to providing the names and phone numbers of possible interview subjects, they helped to schedule and make arrangements for the interviews. When necessary, they also served as translators because a large share of the Crucian fishers spoke mostly Spanish. Additional information was gathered during the Fishery

Advisory Council meetings. Survey data was complemented with the 2003 U.S. Virgin Islands' commercial fishermen census and the landings statistics databases to obtain a more holistic perspective on fishing activities in the island. For space sake, however, only relevant information on demographics and perceptions on the effectiveness of marine reserves is presented in this paper.

In the following section we illustrate the demographic characteristics of the sample and introduce the summary statistics of the key findings. To facilitate the discussion we present two broad themes. The first, a biological theme, examines whether fishermen believe that the closures protected spawning aggregations, increased abundance within the closure, replenished resources in adjacent areas and protected fish sensitive areas. The second, a socio-economic theme, explored whether the closures affected fishermen's livelihoods and communities and whether the closures provide alternative employment opportunities. Unless otherwise noted, the tabulated results are derived from the 2005 survey effort. These summary statistics have been contextualized using field notes from the earlier collection effort as well as the follow-up, semi-structured in-person interviews.

RESULTS AND DISCUSSION

Demographic Profile of the Respondents

Most of the survey respondents were male captains, whose ages ranged from 23 to 82 years. About fifty percent of the sampled population was less than 55 years old (Table 1). Seventy four percent of the interviewees stated that they have used the grounds surrounding Buck Island as a fishing ground and eighty-one percent of respondents said they have fished in Lang Bank. Hispanics and Blacks were the predominant ethnic groups in the fishery (Table 1). Hispanics and Black made up about 56% and 40% of the sample, respectively. Levels of formal education ranged from elementary school to college. Approximately two thirds of the fishermen interviewed did not complete high school (Table 1).

Survey respondents' fishing experience ranged from 5 to 67 years, averaging 24 years. About 56% of the sampled fishermen had at least 20 years of fishing experience (Table 1). They reported using a variety of fishing gears, including traps, spears, trammel and gillnets, hook and line, and SCUBA. Sixty five percent of the respondents were married (Table 2). Fishermen's households had between one and eight members (including the fisherman), with an average of three members per household. About 73% of the respondents derived 50% percent or more of their household income from fishing activities. Seventy one percent of the households had only a single member deriving some of its income from fishing (Table 2).

¹Fishermen were also given the opportunity to respond 'don't know' or 'no answer'.

Table 1. Demographic characteristics of respondents.

Demographic characteristics	Number	Percentage
Captain	83	85
Age of fisherman (years)		
<25	1	1.11
25-34	6	6.67
35-44	16	17.78
45-54	23	25.56
55-64	31	34.44
65-74	11	12.22
>75	2	2.22
Ethnicity		
Black/West Indian	37	39.78
Hispanic	52	55.91
White	4	4.30
Formal education attainment		
Elementary School	20	22.47
Junior High School	30	33.71
Some High School	9	10.11
High School	26	29.21
Some College	2	2.25
College	2	2.25
Fishing experience (years)		
0-4	0	0
5-9	11	12.36
10-14	12	13.48
15-19	16	17.98
20-24	17	19.10
25-29	10	11.24
>30	23	25.84

Table 2. Demographic characteristics of respondents (continued).

Demographic characteristics	Numbers	Percentage
Marital Status		
Single	8	8.42
Married	62	65.26
Divorced	9	9.47
Widow	1	1.05
Other	15	15.79
Household size (including fishermen)		
1	6	6.38
2	33	35.11
3	20	21.28
4	19	20.21
>4	16	17.02
Household members that earn income from fishing (including fishermen)		
0	16	17.02
1	67	71.28
2	9	9.57
3	1	1.06
4	1	1.06
Percentage of income derived from fishing		
0-24%	21	23.08
25-49%	4	4.40
50-74%	14	15.38
75-100%	52	57.14

Attitudes Towards the Biological Performance of Marine Closures

Does the closure effectively protect spawning aggregations? — This study reveals that there is no consensus of opinion regarding the BIRNM expansion and the red hind seasonal closure's ability to successfully care for spawning aggregations. Approximately 39% of the respondents felt that the expansion of BIRNM effectively protects spawning aggregations whereas 37% were irresolute (i.e., responded neutrally, did not know or failed to answer this question) and 24% of respondents dissented (Table 3). Chi-squared tests indicated that the observed distribution of fisherman's beliefs was not statistically significant from a distribution expected by chance ($\chi^2 = 3.6211$, $df = 2$, $p > 0.16$) confirming that the population of fishermen was ambivalent about its usefulness. Fishermen's ambivalence may be partially explained by fishermen's belief that the BIRNM mainly protects spawning aggregations around the reefs, which compose a small percentage of the newly expanded area. Fishermen deemed that the recent expansion did not afford any additional protection to spawning aggregations since these were already well taken care of by the original boundaries. In addition, fishers questioned the size of the expansion since it extended into depths of 5,000 ft. Most fishermen expressed their frustration, because they did not understand what was being protected at those depths and felt that the designation overreached since it extended far beyond what it meant to protect.

St. Croix fishermen were equally ambivalent about the performance of the red hind seasonal closure. The distribution of opinions closely mirrored that for the BIRNM (39% assented, 38% were unsure, 23% dissented) underscoring fishermen's hesitation about its utility ($\chi^2 = 4.4421$, $df = 2$, $p > 0.11$, Table 4). These results are consistent with recent biological assessments. For instance, Whiteman *et al.* (2005) report a decrease in the age and length of sexual maturity of red hind suggesting that the selective removal larger males has resulted in less fecund females which are maturing sooner. Nemeth *et al.* (2006)

argue that the slow recovery of the red hind spawning aggregation is partly due to poaching. Poaching occurs due to the remoteness of the closure and the shape of the western boundary, which complicates monitoring, and enforcement. They also note that the spawning aggregation is only 600 meters away from the western boundary, which makes it vulnerable to over-exploitation since fishermen tend to operate along the edges of the closure. Despite this, in the follow-up interviews fishermen stated that they viewed the red hind seasonal closure more favorably than the BIRNM. Nevertheless, many fishermen complained that by the time the area was re-opened; the red hind had already dispersed and that they were not available for the remainder of the year. A few fishermen claimed that the productivity of the area had not changed since the implementation of the closure, because there have always been plenty of fish out there.

Does the closure improve fish abundance within the closed area? — Most fishermen believed that the BIRNM enhances fish abundance within its boundaries (Table 3). Fifty-five percent of the respondents believed that the expansion of BIRNM increased the numbers of lobster, conch, snapper and grouper. Many fishermen added that although they do not fish inside the monument, they believe that, in theory, the reserve should increase fish abundance within. Forty percent of the survey participations were irresolute and the remaining 5% of the respondents begged to differ. Recent work by Pittman *et al.* (2008) shows that over colonized hard bottom habitats, aggregate fish biomass (all fish combined) and herbivore biomass were higher inside the BIRNM than outside. However, they report that over sandy, vegetated sediments the biomass of piscivorous fish was higher outside the BIRNM, which they ascribed to habitat preferences of infrequently occurring elasmobranchs (i.e., sharks and rays) rather than to the ineffectiveness of the reserve⁶. On a family basis, Pittman *et al.* (2008) found that the mean biomass of Lutjanidae (snappers) and Scaridae (parrotfish) over colonized hard bottom were higher inside the BIRNM. No statistical differences for the mean Serranidae (grouper) biomass were detected between no-take and take

²Spawning aggregations serve as a common reproductive strategy for many reef fish species. Depending on the species, the duration and migrations to spawning sites varies. Smaller reef fishes such as wrasses, surgeonfishes and parrotfishes undergo daily or monthly migrations over short ranges whereas larger reef fishes like snappers and groupers undergo seasonal migrations over tens to hundreds of kilometers (Cummings *et al.* 1997, Nemeth *et al.* 2006, Olson *et al.* 1979, Sadovy 1976, Whiteman *et al.* 2005). Predictable spawning events and strong site fidelity makes reef fish species vulnerable to overexploitation (Nemeth *et al.* 2006)

³Red hind (*Epinephelus guttatus*) is a protogynous hermaphrodite which switches from male to female at about 32 to 38 cm total length (TL) and have an expected fecundity between 500,000 to 1,000,000 eggs per female (Nemeth *et al.* 2006, Whiteman *et al.* 2005). According to Whiteman *et al.* (2005) research, Lang Bank red hind are maturing at smaller sizes (~30 cm TL), which is expected to generate reproductive yield of 250,000 eggs per female.

⁴Nemeth *et al.* (2005) argue that modifying the western boundary to follow a north-south line of longitude rather than the current southeastern bearing would improve enforcement and compliance.

⁵Nemeth *et al.* (2005) suggests that the western boundary be moved at least 3 km to create a buffer zone between the spag and the edge of the closure.

⁶No statistical differences were detected between inside and outside BIRNM for piscivorous fish biomass over colonized hard bottom and seagrass

Table 3. Fishermen's perceptions regarding the biological performance of the expansion of the Buck Island Reef National Monument. Note: The first value is the percentages for each Likert category and the value inside the parenthesis is the number of responses.

Biological perceptions about the expansion of the BIRNM	Answer							Chi square tests	
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know	No response	χ^2	P-value
Protects spawning aggregations	32.63 (31)	6.32 (6)	11.58 (11)	7.37 (7)	16.84 (16)	8.42 (8)	16.84 (16)	3.6211	>0.16
Increases fish abundance within the closure	44.21 (42)	10.53 (10)	11.58 (11)	1.05 (1)	4.21 (4)	11.58 (11)	16.84 (16)	36.7789	>0.0001
Increases fish abundance outside the closure	28.42 (27)	15.79 (15)	9.47 (9)	4.21 (4)	8.42 (8)	12.63 (12)	21.05 (20)	18.3368	>0.0001
Protects fish sensitive sites	31.58 (30)	9.47 (9)	9.47 (9)	6.32 (6)	10.53 (10)	11.58 (11)	21.05 (20)	11.6421	>0.0030
Restores or maintains habitat quality	31.58 (30)	9.47 (9)	7.37 (7)	5.26 (5)	10.53 (10)	15.79 (15)	20 (19)	13.2211	>0.0013

Table 4. Fishermen's perceptions regarding the biological performance of the red hind seasonal closure. Note: The first value is the percentages for each Likert category and the value inside the parenthesis is the number of responses.

Biological perceptions about the red hind seasonal closure	Answer							Chi square tests	
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know	No response	χ^2	P-value
Protects spawning aggregations	31.58 (30)	7.37 (7)	6.32 (6)	3.16 (3)	20 (19)	8.42 (8)	23.1 (22)	4.4421	>0.11
Increases fish abundance within the closure	34.74 (33)	5.26 (5)	11.58 (11)	3.16 (3)	10.53 (10)	11.58 (11)	23.16 (22)	17.0737	>0.0002
Increases fish abundance outside the closure	24.21 (23)	9.47 (9)	11.58 (11)	5.26 (5)	10.53 (10)	13.68 (13)	25.26 (24)	17.2000	>0.0002
Protects fish sensitive sites	22.11 (21)	6.32 (6)	7.37 (7)	7.37 (7)	22.11 (21)	11.58 (11)	23.16 (22)	3.3053	>0.1915
Restores or maintains habitat quality	26.32 (25)	9.47 (9)	3.16 (3)	5.26 (5)	20 (19)	12.63 (12)	23.16 (22)	2.9263	>0.2315

areas. Pittman *et al.* (2008) did not compare conch and lobster biomass across management regimes.

When we inquired about the ability of the red hind seasonal closure to augment fish abundance within its boundaries, 46% of the respondents were irresolute, 40% coincided with the statement, and 14% disputed it (Table 4). Unlike the BIRNM expansion case, where fishers indicated that the abundance of many reef-fish and shellfish species increased, fishermen stated that the main beneficiaries were a few reef-fish species such as red hind, grouper, and snapper species. In general, fishermen viewed the expansion of the BIRNM more favorably than the red hind closure perhaps because of the permanent nature of the former. Chi-squared tests found the distribution of beliefs could not be explained by chance suggesting the presence of defined, yet diverse perceptions among fishermen (BIRNM: $\chi^2 = 36.7789$, $df = 2$, $p > 0.0001$, and red hind: $\chi^2 = 17.0737$, $df = 2$, $p > 0.0002$).

Does the closure improve fish abundance in adjacent fishing areas? — Despite the wide held belief that closures enhanced fish production within, fishermen tended to be more skeptical about whether they could replenish fish biomass outside their boundaries. In the case of the expansion of the BIRNM, 44% of respondents claimed to have perceived higher fish abundance outside the monument, whereas 43% were irresolute and 13% dissented with this opinion (Table 3; $\chi^2 = 18.3368$, $df = 2$, $p > 0.0001$). In the case of the red hind seasonal closure, 50% of the fishermen were irresolute (Table 4). Thirty four percent perceived increases in abundance whereas 16% did not ($\chi^2 = 17.2000$, $df = 2$, $p > 0.0002$). Of those that agreed, some observed increases in grouper and hind abundance. Many of the fishermen were skeptical that any fish caught in the adjacent areas originally inhabited those waters. Lower acquiescence percentages for the red hind seasonal closure (relative to the BIRNM) suggest that any spillover (if present) is smaller than the one evidenced in the BIRNM. This trend was also observed in the follow up interviews.

Does the closure effectively protect fish sensitive sites? — Surprisingly, 59% of the fishermen were irresolute or did not believe that the expansion successfully protected fish sensitive sites (42% were irresolute, 17% dissented; $\chi^2 = 11.6421$, $df = 2$, $p > 0.0030$; Table 3). The comparatively low acceptance percentage was unexpected because many of the target species, especially reef-fish species, have high degrees of site fidelity and 55% of the respondents had stated earlier that the monument enhanced fish abundance within its boundaries. Hence, we would have expected a tighter correlation between enhanced fish abundance and effective fish habitat protection. The lack of a closer correlation; however, may be capturing that marine reserves do not protect fish sensitive sites and habitat quality against many natural and anthropogenic stressors such as diseases, tropical storms and hurricanes, bleaching and rising sea surface temperatures. For example, in 1983, St. Croix experienced a massive die-off of the black sea urchin (*Diadema antillarum*) for reasons still unknown. This die-off removed a major grazer of algae, which in turn, caused blooms to occur and reduced overall coral settlement and larvae recruitment ever since (Rogers and Beets 2001, Tobias 2004). In 1989, Hurricane Hugo razed the southeast reef system of the BIRNM. Hurricanes and various coral diseases such as White band disease have caused a 95% loss in live coral coverage of *Acropora palmata* in many shallow reef sites (Mayor *et al.* 2006, Tobias 2004, Turgeon *et al.* 2002). Most fishermen (72%) were irresolute (42%) or did not believe (30%) that the red hind seasonal closure effectively protected fish sensitive sites ($\chi^2 = 3.3053$, $df = 2$, $p > 0.1915$; Table 4) probably because it only affords temporary refuge.

Attitudes Towards the Socioeconomic Impacts of Marine Closures

Has the closure adversely impacted their ability to support themselves and their families? — While wide ranging views regarding the conservation benefits of both closures were articulated, most fishermen were adamant about their adverse socioeconomic impacts. When asked if the BIRNM expansion adversely impacted their ability to support themselves and their families, 57 percent assented (51 of the 54 respondents strongly agreed, Table 5). Only 19% of the fishers did not feel that the expansion impacted them ($\chi^2 = 24.0211$, $df = 2$, $p > 0.0001$)⁷. Fishermen explained that the expansion took away one of their historically, most productive fishing grounds, particularly for conch and lobster. Moreover, the expansion resulted in the removal of a popular fish-aggregating device (FAD), which the fishers relied upon to attract a variety of pelagic species such as dolphinfish and wahoo. Without access to these rich grounds, fishermen stated that harvesting the

same amount of fish takes considerably longer.

Most fishers agreed that the expansion did not necessarily impact their harvesting methods, but did force them to go further to unfamiliar fishing grounds. One fisherman underscored the risks associated with diving in other areas, which he believes includes harmful pollutants and unsafe conditions. Multiple fishers also mentioned that Buck Island used to provide them shelter and protection from bad weather and heavy seas. Now, they are forced to go out to open waters regardless of the weather condition. Adopting a new annual round can be arduous since it requires fishermen to learn additional skills and knowledge about breeding areas and patterns, feeding habits, and migration patterns (Agar *et al.* 2008). The fishers also remarked that the increased cost of fuel coupled with the need to now go further out to fish has significantly impacted them financially. Few fishers did not feel that the expansion made it more difficult for them to support themselves and their families. One of them said that it hurt initially, but that he was able to adjust to fishing in other areas. Another acknowledged that the change did require him to travel further to other fishing grounds, but did not feel that the financial impact of this was great enough to affect his ability to provide for himself and his family.

Akin to the BIRNM experience, the majority of the respondents (57%) believed that the red hind seasonal closure negatively impacted their ability to support themselves and family (Table 6, $\chi^2 = 24.9053$, $df = 2$, $p > 0.0001$). When asked to explain the adverse impacts, their responses varied. Most of the fishers agreed that Lang Bank's red hind closure did not impact their harvesting methods but influenced their location choices. One fisher explained that during the red hind spawning season a fisher could catch 400-500 pounds of red hind, but once the season was over the fish leave and it is difficult to even catch 100 pounds of this species. Another fisher explained that bad weather on Lang Bank only allows for about five good months of fishing in that area anyways, which he suggests is already a significant restriction. He also stated that the weather itself is sufficient punishment and that no additional restrictions are warranted. Still others suggested that relative to the impacts of the red hind seasonal closure, the dislocation brought about by the expansion of BIRNM was significantly more severe. Finally, fishermen lamented that because of the increasing number of closures surrounding the island, the only place left to fish is on the south side of the island⁸. The southern waters are reportedly contaminated by the effluent from the Cruzan rum factory and HOVENSA oil refinery, and by runoff from a variety of sources including the Anguilla landfill and sewage spills. This human health issue was a recurrent

⁷Our results are consistent with Uwate *et al.* (2001) [21] study which suggested that the expansion would adversely impact about 46 fishermen, each of whom would forgo about 74,000 lbs of fish (\$54,000) annually. However, they noted these figures may overstate their losses since the stated forgone landings (and revenues) were ten times higher than their preliminary estimates based on catch reports.

issue raised during the follow-up interviews. One fisher admitted that he and other fishers have had to lie about where they get their fish, because no one wants to purchase fish from the polluted south side of the island. Another fisher exclaimed that it is not the fishers, but the pollution and the runoff from the rum factory and other industries that are killing the reefs. "Who is looking at that though?" he inquired.

Has the closure created social or economic hardships for the fishing community? — Most fishermen believed that the closures created significant social or economic hardships for the fishing community. Nearly 67% of respondents (64 fishers) felt that the expansion of BIRNM creates social or economic hardships ($\chi^2 = 52.1895$, $df = 2$, $p > 0.0001$, Table 5), and an equal number felt that the red hind closure did the same ($\chi^2 = 53.0737$, $df = 2$, $p > 0.0001$, Table 6). Less than 9% of the respondents dissented that the closures generated adverse communal impacts.

Fishers remarked that the closures adversely impacted the fishing community in various ways. It exacerbated the growing competition between the commercial and recreational sectors since these groups compete for the same species and fishing grounds. Additionally, full-time commercial fishermen expressed that charter vessels are forcing them out the market since charter vessels are selling their catch at lower subsidized prices from the passenger fees. Commercial fishermen feel that these cross-subsidized prices are forcing them out of the market. Multiple commercial fishers expressed their belief that charter fishers should not be allowed to hold commercial licenses. Like with the charter fishers, competition with recreational fishers has also been of concern to the commercial fishers. Most recreational fishers also have other means of income which means they do not rely on the fish like commercial fishers do. Yet they expend the same resource that the commercial fishers depend upon, often targeting the same species. Others, however, noted that the closures have actually decreased competition within the commercial fishery, because many of them have had to exit the fishery in favor of more profitable professions, often construction. He clarified, however, that he still believes current fishing grounds are over crowded, in part due to the closed areas.

Some fishers, felt that the impacts of the closures have extended beyond the fishing community, and explained that they have had heavy social and economic impacts on the entire St. Croix community. More than one fisher pointed to how the closures impact future generations. Many of the fishers employ kids off of the street to help them as crew and in selling their catch. Now that their cost

of production has increased and reliable fishing grounds have decreased, they cannot afford to pay as many helpers. Therefore there are fewer opportunities for employment in the fishery for the future generations. The fishers believe that it is important that the youth be provided these opportunities so that they learn responsibility and stay out of trouble. The marine closures have also affected the community as a whole because as the cost to the fishers has increased, they have had to increase the price at which they sell the fish. For this reason, it is not merely the fishers that have been hurt by the closures, but everyone who buys from them also. This includes individuals and restaurants.

It should, however, be noted that some fishers, clarified that there are not as many impacts from the red hind closure as from the BIRNM expansion. One says that the fishing community is highly reliant on Lang Bank, but that the red hind closure alone hasn't had much of an impact. Another explained that fishers are still able to get conch and lobster from outside of the closure on Lang Bank.

Has the closure helped to maintain or enhance employment opportunities? — Finally, because of the close link between marine reserves and tourism, we inquired whether they assisted in the generation of alternative sources of employment. Only twenty-nine percent of the fishermen believed the expansion of BIRNM contributed to the generation of employment opportunities whereas only 16 percent assented in the red hind case (BIRNM $\chi^2 = 1.4105$, $df = 2$, $p > 0.4940$; red hind $\chi^2 = 16.2526$, $df = 2$, $p > 0.0003$). The difference between the two closures likely reflects the employment alternatives offered by the leisure and support industry that cater to tourists who hike and/or snorkel and SCUBA dive in the monument. The Lang Bank was described as too dangerous for tourists by local fishermen. Despite the original acceptance rates for the various closures, follow-up interviews indicated that neither the expansion of BIRNM nor the red hind closure provided the commercial fishers with alternative income opportunities, or means to alleviate their financial displacement. Fishers reiterated that closures severally limit employment opportunities, particularly those for the island's youth. With higher fuel cost and lower returns, the fishers cannot afford to employ as many helpers as they had in the past. In addition, the low educational achievement rates further reduce fishermen employment opportunities since St. Croix's main industries, manufacturing and construction, require specialized skills. St. Croix has a small leisure and hospitality industry relative to St. Thomas and St. John, which limits supply for low-skill jobs (Agar *et al.* 2008).

⁸In addition to the BIRNM and Red Hind seasonal closure, fishermen fishing grounds are restricted by the East End Marine Park, Hovensa/Homeland Security closed areas, and the mutton snapper and queen conch seasonal closures. The moratorium on new fishing licenses and the recent enforcement of the gill and trammel net ban further limit fishermen's and their helpers livelihood opportunities.

Table 5. Fishermen's perceptions regarding the socio-economic performance of the expansion of the Buck Island Reef National Monument. Note: The first value is the percentages for each Likert category and the value inside the parenthesis is the number of responses.

Socio-economic perceptions about the expansion BIRNM	Answer							Chi square tests	
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know	No Response	χ^2	P-value
Adversely impacts fishermen's ability to support themselves and families	53.68 (51)	3.16 (3)	5.26 (5)	4.21 (4)	14.74 (14)	4.21 (4)	14.74 (14)	24.0211	>0.0001
Generate hardships to local the fishing community	61.05 (58)	6.32 (6)	2.11 (2)	1.05 (1)	8.42 (8)	5.26 (5)	15.79 (15)	52.1895	>0.0001
Generate alternative sources of employment	22.11 (21)	7.37 (7)	5.26 (5)	9.47 (9)	29.47 (28)	9.47 (9)	16.84 (16)	16.2526	>0.0003

Table 6. Fishermen's perceptions regarding the socio-economic performance of the red hind seasonal closure. Note: The first value is the percentages for each Likert category and the value inside the parenthesis is the number of responses.

Socio-economic perceptions about the red hind seasonal closure	Answer							Chi square tests	
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know	No response	χ^2	P-value
Adversely impacts fishermen's ability to support themselves and families	54.74 (52)	2.11 (2)	6.32 (6)	4.21 (4)	12.63 (12)	5.26 (5)	14.74 (14)	24.9053	>0.0001
Generates hardships to local the fishing community	64.21 (61)	3.16 (3)	2.11 (2)	2.11 (2)	6.32 (6)	7.37 (7)	14.74 (14)	53.0737	>0.0001
Generate alternative sources of employment	10.53 (10)	5.26 (5)	5.26 (5)	5.26 (5)	44.21 (42)	9.47 (9)	20 (19)	1.4105	>0.4940

CONCLUSIONS

Despite the growing use of marine protected areas and seasonal closures in St. Croix, there have few scientific evaluations of their performance, particularly socio-economic evaluations. Our study reveals that large number of commercial fishermen believe that the BIRNM expansion effectively increases fish abundance within the closure, however, they were generally skeptical about other purported biological benefits such as protecting spawning aggregations, exporting fish biomass outside its boundaries, and protecting fish sensitive sites. In the case of the red hind seasonal closure, opinions regarding the perceived conservation benefits were more diverse. Our results support the findings of other biologically-oriented studies (Nemeth *et al.* 2006, Pittman *et al.* 2008, Whiteman *et al.* 2005).

Our study also finds that fishermen were adamant about the adverse impacts on their livelihoods and communities, brought about the closures. Fishermen mentioned that the loss of productive fishing grounds forced them to fish longer and further away. Fishermen were also skeptical about the ability of the closures to

generate alternative sources of employment, particularly for the island's youth. Furthermore, they remarked that the increasing number of closures and the limited amount of shelf area has forced them to harvest in waters exposed to industrial and sewage effluent.

The results of these case studies provide useful insight to policymakers. First, it underscores there is considerable hesitation among fishermen regarding the biological performance of the closures. While closures have the potential to positively contribute to the restoration of local ecosystems, fishery managers should recognize that there is considerable uncertainty associated with these management tools and should set reasonable expectations and timelines to evaluate them (Agardy *et al.* 2003). Local fishermen have repeatedly stated that they do not oppose the use of closures and that they welcome management measures to protect the marine environment that they depend on. However, they feel that they have considerable local ecological knowledge which they believe should be employed in cooperative research partnerships and also utilized in the decision making process. Cooperative research could be a useful vehicle for periodic performance

assessments, which could help to educate fishermen, resource managers and policy-makers alike, reduce uncertainty, and provide the basis for revising fishery management plans. Perhaps a useful starting place would be the red hind seasonal closure given Whiteman *et al.* (2005), Nemeth *et al.* (2006), and the present work.

In addition, policymakers should recognize that relying on biological metrics alone can lead to biased assessments because short-term biological gains may come at the expense of social dislocation (. Short-term biological gains will probable fade away unless social issues are addressed [4, 5, 15] Failing to design closures that balance biological with social and economic considerations can marginalize fishing communities, which may either oppose to their implementation or lose interest shortly after their adoption (Christie 2005). These conflicted social dynamics have contributed to elevated failure rates approaching 90% in some countries (White *et al.* 2002). Hence, greater care must be afforded to ensure that fishermen participate in a meaningful way in the management process, particularly when the proposed management measures can potentially jeopardize their livelihoods and lifestyles. In the recent implementation of the BIRNM expansion, fishermen felt that meaningful opportunities to voice their opinions and concerns were absent. Furthermore, they stated that the biological gains from expansion were nominal in relation to the increased cost of forgoing productive lobster, conch and pelagic fishing grounds. Finally, fishermen remarked that closer cooperation and coordination between the various federal and territorial resource management agencies was warranted because the growing number of closures and gear restrictions were encroaching on their ability to support themselves and their families.

ACKNOWLEDGEMENTS

We would like to express our gratitude to all the fishermen, who kindly shared their time and knowledge of the fishery with us. Also, we would like to acknowledge the assistance of William Tobias from the U.S. Virgin Islands' Department of Planning and Natural Resources, and Gerson Martinez and Edward Schuster from the St. Croix Fishery Advisory Committee. We thank them for providing valuable insight into U.S. Virgin Islands fisheries and for serving as liaisons to the St. Croix fishing community. Useful comments were also provided by Maria Villanueva, Dr. Owen Kahn, and Dr. Daniel Suman. NOAA Coral Reef Conservation Program supported this research.

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