Characterization of stakeholder uses in marine protected areas in support of establishing limits of acceptable change

[Five case studies in the coastal and marine natural reserve system of Puerto Rico]

June 16, 2009

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1. Introduction

This report discusses the characterization of commercial and recreational stakeholder uses in selected Natural Reserves (NR) with coastal and marine components in the Commonwealth of Puerto Rico. The effort, conducted as a series of case studies, is intended to present different methodological approaches to characterizing stakeholders and their use patterns – including use types, frequencies, and locations, perceptions on resource conditions, and views on crowding and related social carrying capacity conditions, as a means by which to provide managers with examples of human dimensions research in support of evaluating limits of acceptable change (LAC) within the island's NR system. The case studies are not intended to provide guidance on establishing LAC, which is a separate, iterative process based on identifying those natural resource and social conditions that are deemed acceptable and how the conditions can be maintained (McCool, 1996; Stankey et al., 1985). Thus, in determining (a) stakeholder use patterns within selected reserves, (b) stakeholder perceptions on resource and use conditions, and (c) stakeholder views on management alternatives, the case studies provide baseline information that could be incorporated into an LAC or related framework (Nilsen and Tayler, 1998).

Limits of acceptable change framework

Protected areas in the US have considered the concept of carrying capacity since the 1930s, when visitor use totals first increased to levels requiring visitor management (NPS, 1997). Carrying capacity in visitor management settings was derived from the ecological understanding of the concept, which refers to the absolute number of organisms that an area/habitat can sustain, beyond which the area/habitat declines and is no longer suitable to sustain the increased base of organisms. However, it was recognized in later decades that carrying capacity as applied to controlling human impacts in protected areas was affected by more than the changes in ecology and habitat damage; visitor demands, behavior, and experiences, which are based on factors in addition to or other than the natural state of the resource, also affected the carrying capacity of a protected area (Cole and Stankey, 1998). By the 1980s, a view emerged that challenged the carrying capacity framework, arguing that management in protected areas should focus less on quantitative totals as a means by which to control impacts and more on determining which resource and social conditions are desirable and how these can be maintained (Stankey et al., 1985).

First implemented in 1985 in a terrestrial park setting (Stankey et al., 1985), the LAC framework has been utilized increasingly to address recreational use in protected areas (NPS, 1997) and tourism (McCool and Lime, 2001). The framework deviated from the traditional carrying capacity approach in that while the latter was developed to estimate an upper limit of use (or capacity), LAC was established to "focus management on achieving specific objectives, defined as staying within maximum acceptable deviations" (Cole and Stankey, 1998). Thus, LAC shifted the focus from a numerical target, as prescribed under the carrying capacity approach, to the maintenance of desired resource and social conditions. While modified frameworks build on and modify the LAC approach (Nilsen and Tayler, 1998), where each consist of a number of hierarchical stages/steps, the "conceptual core of LAC" (Cole and Stankey, 1998) consists of the following:

1. Agreement that two or more goals are in conflict;
2. Establishment that all goals must be compromised;
3. Designation of one conflicting goal as the ultimate constraining goal and another as the initial constraining goal;

4. Determination of LAC indicators and standards and the monitoring of the ultimate constraining goal;
5. Acceptance of ultimate constraining goal to be compromised up to a limit of acceptable change;
6. Management of the initial constraining goal so that the ultimate constraining goal is not compromised beyond the limit of acceptable change.

In coastal and marine protected areas, where there often exist conflicting goals of ensuring resource protection while allowing recreational, commercial, and other activities, the LAC framework as described above recommends that an iterative process may be developed such that it is acknowledged that allowed activities may conflict with resource protection objectives (step 1), and that there is a need to allow for compromise such that neither allowed activities or resource protection excludes the other goal (step 2). As resource protection is prioritized in NR, it can be designated as the ultimate constraining goal, whereas allowed activities can be designated as the initial constraining goal (step 3). Indicators and standards can be established that, via a monitoring program, observe changes in resource conditions (step 4). If resource conditions decline via allowed activities up to the determined limit of acceptable change (step 5), then allowed activities should be constrained to prevent further degradation (step 6).

Carrying capacity and limits of acceptable change studies in coral reef ecosystems

Research concerning direct recreational impacts in coral reef protected areas (and ecosystems in general) has largely utilized the carrying capacity framework (ex. the total number of divers that a coral reef dive site can host on an annual basis, the appropriate number of mooring buoys to limit vessel use, etc.), but other approaches do incorporate the LAC framework (ex. the zoning of coral reefs to establish high and low intensity use zones that can accommodate visitor use and protect coral reef resources, respectively). While many studies still refer to capacity (see, for instance, Salm et al.'s (2000) marine protected area manual, the IUCN guidelines for marine protected areas (Kelleher, 1999), etc.), management mechanisms addressing resource impact issues increasingly use LAC approaches where the use of indicators monitoring healthy resource conditions and visitor experience satisfaction are favored over numerical targets. Also, biophysical and social factors such as the dynamic nature of coastal and marine environments, the diversity of user expertise and impacts, and shifting social preferences all influence the capacity ceiling (and indeed may represent several different capacities) and are therefore less amenable to a carrying capacity framework than to an LAC framework.

Dixon et al. (1993) introduced the concept of a diver carrying capacity, based on a study conducted of divers on Bonaire's coral reefs. The study determined that areas of high dive use showed lower coral percent cover and that species diversity was higher at low use sites. The study also documented a direct relationship between coral damage and distance from the mooring buoy (where divers often enter and leave the site), with coral cover and species diversity increasing with distance from the mooring buoy. Based on these findings, the authors developed a threshold for dive use, predicting that diver impacts would become apparent once use exceeds a threshold of 4,000 – 6,000 dives per site, per year. Jameson et al. (1999), Hawkins and Roberts (1994) utilized the carrying capacity concept to derive estimates and make recommendations for other areas. Coral reef site rotation and mooring buoy limits were among two examples of how carrying capacity management was and continues to be implemented in various dive destinations.

However, later studies found that education can make a difference in the amount of damage resulting from divers and snorkelers, which suggested that carrying capacity could be increased in sites where dive operations (among other sources) promoted environmentally responsible behavior (Zakai et al. (2002), Tratalos and Austin, 2001; Hawkins and Roberts, 1997; Medio et al., 1997). Other research pointed to user skill (Thapa et al., 2006) and activities such as underwater photography and wildlife viewing (Serour, 2004; Walters and Samways, 2001) that influence the level of resource damage. Similarly, other research, which focused on the socioeconomic conditions, found user perceptions as important as the actual impacts that diving, snorkeling, and related recreational activities have on coral reefs. In such cases, users (and other stakeholders) often establish other baselines on resource conditions than those determined by biophysical research. Lenjak and Ormond (2007) determined that the nationality of visitors to the Red Sea coral reef resorts can establish a baseline coral reef quality as much as could other socio-demographic indicators, such as diving experience and capability. Moreover, as shown as by that research, the baseline can shift significantly as the nationality of tourists, among other socio-demographic and socioeconomic factors, changes at a coral reef location. Inglis et al. (1999) found that diver experience influences views on crowding, and Letson et al. (2005) reported that diver views on resource quality may be related in part to a coral reef site's reputation. These and many other studies demonstrated that carrying capacity cannot necessarily be established as a 'hard' target and suggested instead that an approach that protected resource conditions and use satisfaction be considered.

Many coastal and marine protected areas have established zoning as a means by which to accommodate the conflicting goals of resource protection and recreation and other activities, thereby migrating to an LAC approach in managing uses. Within these types of multiple use protected areas, uses are often zoned according to their impacts. The Florida Keys National Marine Sanctuary (FKNMS), for example, created dive and snorkel only zones, called Sanctuary Preservation Areas (SPA), which capture three quarters of all diving and snorkeling in the Florida Keys (NOAA, 1996). Similarly, other protected areas have 'compromised' by designating areas for high-intensity use. Trunk Bay, a snorkel site in the Virgin Islands National Park, contains a self-guided trail that is heavily used and impacted by snorkelers (Rogers et al., 1988). Plathong et al. (2000) reported that opening up snorkeling trails in the Great Barrier Reef led to considerable damage that was confined mainly around the interpretation areas. Various studies recommended managing snorkeler impacts by keeping snorkelers in designated, high-intensity zones (Roman et al., 2007; Marion and Rogers, 1994), by establishing ecotourism zones that host fewer users (Roman et al., 2007) and by rotating sites (Plathong et al., 2000).

As coastal and marine tourism increases in the present century in the US and elsewhere (US Commission on Ocean Policy, 2004), an LAC approach will be required to establish limits that can be maintained while allowing for other activities, especially in those protected areas that are designated for multiple-use purposes. Zoning and related access strategies as utilized in the Great Barrier Reef Marine Park (Kelleher, 1999) and the aforementioned FKNMS (NOAA, 1996) can serve as effective management options in achieving the objectives of resource protection and use opportunities. In Puerto Rico, an island rich in coral reefs and related ecosystems which highly dependent on a healthy coastal and marine zone for its tourism industry[1], commercial fisheries, and other activities, the implementation of

[1] Tourism is an important segment of Puerto Rico's economy. In 2003-04, an estimated 4.9 million tourists visited the island, and the tourism sector generated over $3 billion (Puerto Rico Tourism Company, 2008). However, the effects of tourism on Puerto Rican coral reefs are largely under studied, and only proxy information – such as the

an LAC framework would be especially beneficial in integrating the goals of resource protection and commercial, recreational, and other uses in the coastal and marine NR system.

The coastal and marine protected area system in Puerto Rico

There are 37 marine protected areas in Puerto Rico, of which most (73%) are NR (Aguilar-Perrera et al., 2006). Two of the marine protected areas are marine reserves. Most NR are designated by Planning Board of the Commonwealth of Puerto Rico (PBCPR), which considers candidate sites submitted by the Puerto Rico Department of Natural Resources (DNER), or Departamento de Recursos Naturales y Ambientales (DRNA). If approved, the NR are designated by the passage of a resolution. Designation via the Puerto Rico Legislature by representatives or senators is another way by which NR are approved. In both cases, DRNA is the agency responsible for managing all natural reserve through its Division of Reserves and Refuges. NR management varies across individual sites, and most do not yet have management plans (Aguilar-Perrera et al., 2006). Activities allowed within NR also vary, with sites such as the La Cordillera NR allowing most uses compared others like the Luis Peña No-take Channel Reserve prohibiting all fishing but allowing other, nonconsumptive uses.

The sites comprising the case studies for this report – Puerto Mosquito Bay NR, Luis Peña No-take Channel Reserve, La Cordillera NR, and Tres Palmas Marine Reserve – were selected in part because of the diversity of uses and interests in each site. Also, the characterization studies developed for the sites represented excellent demonstration projects that could be modified and applied at other sites to determine use patterns and stakeholder perceptions on resource conditions in a straightforward and cost-effective manner. The studies' results, discussed in more detail in the following sections, should thus be considered not only for their usefulness in the sites in which the studies were conducted but also as a primer for future characterization studies that can assist in the development of an LAC framework for individual sites in Puerto Rico's coastal and marine protected area system.

number of vessels in the region, hotel room occupancy rates, and research findings from individual sites – is available to estimate its potential effects (Garcia-Sais et al., 2008).

Methodology

The methodology described in this section is presented in considerable detail such that it may be utilized and/or modified as required to conduct similar studies to address issues of limits of acceptable change, visitor management (via zoning, visitor loads, etc.), and resource protection, among others, as these relate to marine reserve management. Separate approaches were used for the four NR that served as the case studies for this project and the registered vessel survey study.

Registered vessel operator survey study methodology

Upon the completion of the preliminary meeting to consider candidate sites, it was determined that reserves such as Mona Island NR, La Cordillera Natural Reserve, and Luis Peña No-take Channel Reserve – all of which require vessel access – could be best characterized via vessel operator surveys. While other work (Shivlani, 2006; BRC, 1991) has used intercept surveys as a means by which to characteristic vessel traffic patterns and operator views on resource conditions and management, the present approach took advantage of existing regulatory infrastructure (ex. vessel registration offices) and a self-administered survey instrument to conduct registered vessel operator surveys.

The first step in the implementation of the registered vessel operator survey consisted of the development of a concise survey instrument (no greater than 2 pages) that asked questions on areas and frequency of use, operator experience, popular activities, the amount of space available, perceptions on the number of vessels that constitute crowded conditions, and views on management alternatives to reduce or spread out use in a given area (see Appendix 1 for a copy of the survey instrument). The next step comprised a month-long, pilot survey session, which was conducted in the San Juan vessel registration office and which led to the completion of 94 pilot surveys. The pilot survey contained a total of 13 questions and a map, which persons entering the registration office were asked to complete. The third step included the dissemination of survey copies in three locations across Puerto Rico to maximize coverage for capturing use patterns in and perceptions concerning the aforementioned NRs. Officials in vessel registration offices in Mayaguez (western Puerto Rico), San Juan (northern and northeastern Puerto Rico), and Ceiba/Fajardo (eastern Puerto Rico) were contacted first by phone to explain the project; then, each official was provided with copies of the survey in person, with a follow-up discussion on the objectives of the effort and the self-administered methodology. While officials were requested to encourage participation, the general approach was to leave copies of the survey available in each office such that registrants could fill out surveys on a voluntary basis. This step, also called the field survey session, lasted a total of six months. The final step in the process consisted of the collection, data entry, and analysis of surveys. The steps are shown in summary format in Figure 1.

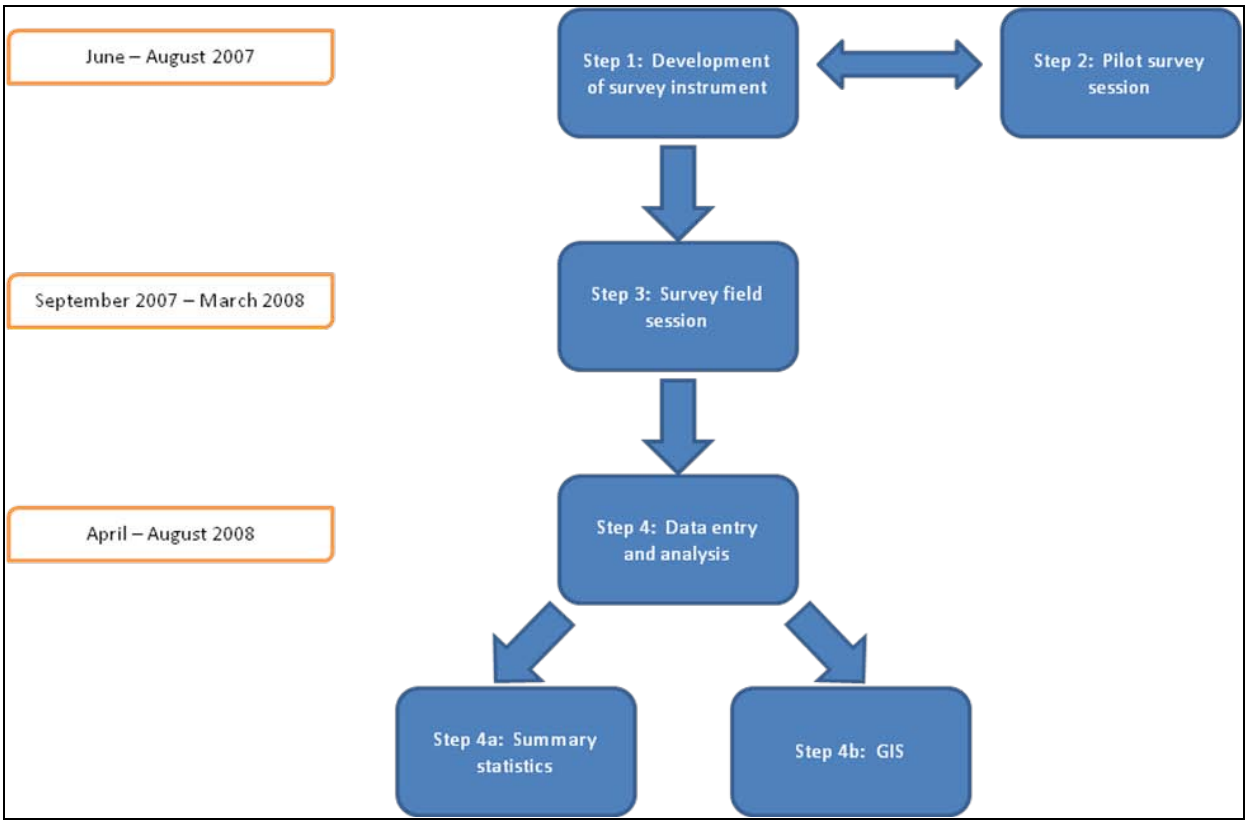


Figure 1: Registered vessel survey process

Puerto Mosquito Bay Natural Reserve

The Puerto Mosquito Bay Natural Reserve (PMBNR) was selected as one of the four case study sites due to the emerging conflict surrounding visitor loads and especially development in upland areas affecting the quality of the bioluminescence (Shivlani, 2007b; Mitchell, 2005). Due to the reserve's attraction on the island of Vieques, it provided an excellent case study via which to evaluate stakeholder groups' views on the condition of the bay, current use conditions, and perceived threats and solutions. In effect, PMBNR served to demonstrate that although limits of acceptable change may vary across stakeholder groups (ex. water operators versus conservationists), scientific information on reserve conditions (ex. levels of bioluminescence, rates of sedimentation) may provide a more objective limit on acceptable visitor loads.

In the case of Vieques, information gathered from a previously completed study (Shivlani, 2007b), which evaluated the preference of user groups on the siting and function of marine protected areas in Vieques, was utilized to determine stakeholder uses of and views towards limits of acceptable change in PBMNR. A series of interviews conducted from 2005-06 with water operators, commercial fishers, DRNA and other local agency officials, and conservation and public interest group members were used in conjunction with results from a visitor survey study to develop the case study. The PBMNR example showed how existing data could serve to complement further efforts, even where the focus of the previous studies may not be directly related to the present one.

Luis Peña Channel No-take Natural Reserve

The Luis Peña Channel No-take Natural Reserve (LPCNR) case study was developed by directly interviewing the group of dive and snorkel operators known to use the reserve on a regular basis. Additional information on visitor use of the reserve was also applied to the case study (Loftin, 2004). Together, the new information gathered by conducting an effective census of dive and snorkel operators and the aforementioned case study combined to characterize the overall uses of the reserve and operator and visitor views on the overall space available for recreation within the LPCNR. The methodology utilized was straightforward in that is was focused mainly on identifying the different users of the reserve and thus did not involve the use of advanced field techniques (ex. surveys, mapping, etc.) or the gathering of detailed user group information (ex. demographic profiles, use patterns, views on individual resource conditions, management effectiveness, etc.).

La Cordillera Natural Reserve

The La Cordillera Natural Reserve (LCNR) case study represented the most intensive case study conducted as part of the project. It involved the development of a survey instrument (see Appendix 2 for a copy of the survey instrument) that asked questions of water operators in the reserve related to areas of use, frequency of use, types of activities, changes in use within the reserve, changes in resource conditions, and views on crowding and preferred use totals (on a trip basis). Because operators taking trips within the reserve are required to maintain a concessionaire license, it was possible to identify all users and the methodology consisted of conducting a census of the stakeholder group.

Also, as part of the case study, a separate vessel operator survey map was created for the surveys left at the Puerto del Rey vessel registration office in northeastern Puerto Rico (located in the largest marina in the Caribbean, from where many private vessels access the LCNR). The objective was to conduct an area-specific, self-administered survey such that the results would show private vessel, general use patterns around and inside the LCNR.

Tres Palmas Marine Reserve

The Tres Palmas Marine Reserve (TPNR) case study was completed via information gathered from stakeholder interviews. The methodology adopted for the case study involved key informant interviews, including discussions with members of a regional academic institution involved in the reserve development process, a member of a nongovernmental organization, commercial fishers, and water operators.

Methodology efficacy

As the focus of the project was the development of several case studies that could be used as examples on how to gather information necessary to answer questions related to limits of acceptable change (in its broadest definition), the methodology adopted for each case study varied based on the characteristics of the each site and the resulting applicability of the approach. However, there were several common themes within each case study. These included:

- The determination of current use patterns, as defined as the total amount of use, the different types of uses (in terms of sources and activities), and frequency and intensity of uses;
- The evaluation of changes in use patterns
- The identification of perceived impacts resulting from changes in use patterns on the perceived biophysical and socially acceptable integrity of the site;

The project methodology generally avoided questions related to generating a suitable number for users or extent of use for each case study site. As discussed by proponents of the LAC framework, numbers tend to vary considerably based on management objectives, activity types, and user level of experience, among other factors (McCool and Lime, 2001; Cole and Stankey, 1998; McCool, 1996; Stankey et al., 1998). Although studies have considered carrying capacity for diver and snorkelers in coral reefs and other marine habitats (see Introduction), more recent literature has shown how the capacities can change, based on user experience, user education, and other prevailing biophysical impacts, as well as social perceptions on the overall health of sites. Thus, the project focused mainly on showing *how* basic use and related information could be collected and applied to characterize stakeholder and visitor groups for NRs and less so on the management of uses and user impacts.

The project methodology applied a series of field and literature-based approaches to develop each case study (see Table 1 for a summary of the various approaches used in each case study). In all cases, existing literature was referenced. For the vessel operator project, literature research consisted of evaluating previous boater survey studies that addressed boater use pattern and activities (ex. BRC, 1991). For the reserves' case studies, literature research included a review of existing management plans, where these were available, and other biophysical and socioeconomic/human dimensions research conducted inside or around the reserves. Two of the reserves – PMBNR and LPCNR – included the application of pre-existing data in the completion of their case studies; the value of pre-existing data was such that it eliminated the need for original field research and lowered project costs.

Table 1: Methodologies used in each study

Study	Literature research	Pre-existing data	In-person surveys	In-person interviews	Self-administered surveys	Mapping
Vessel operators	Y	N	N	N	Y	Y
PMBNR	Y	Y	N	N	N	N
LPCNR	Y	N	Y	N	N	N
LCNR	Y	Y	Y	Y	Y	Y
TPNR	Y	N	N	Y	N	N

Field techniques, including in-person surveys and interviews, were used for LPCNR, LCNR, and TPNR. These were among the most time consuming and expensive components of the project and thus were used sparingly and only when considered essential. Otherwise, in larger efforts like the vessel operator study, self-administered surveys (where costs are mostly related to study development, materials, and data entry) were used as a cost-effective alternative to intercept surveys.

Finally, mapping was used in two studies in different ways. In the vessel operator study, respondents completed maps provided to them on their own. While this led to higher rates of incomplete maps than could have been obtained by intercept surveys, the approach did save on time and expenses, and the large number of surveys completed compensated for the proportionally fewer incomplete maps. In the LCNR study, water operators identified areas of use during an in-person survey. This approach was applied with the group because of the group's small population size and its ability to provide expert (based on experience) information on spatial use.

Results

Results are presented for each of the four studies completed as part of the project. While the vessel operator study results are presented for the three regions in which the study was conducted, the results are also discussed in each case study where these are considered relevant.

Vessel operator study results

The vessel operator survey study was conducted as self-administered surveys in three vessel registration offices located in the same regions as the case studies selected for the project. Data collection commenced in September 2007 and ended in March 2008, comprising a six month survey period. Respondents completed a total of 565 surveys, of which 53.3% were completed in the San Juan registration office, 28.7% in the Mayaguez registration office, and 18% in the Fajardo/Ceiba registration office. Zip codes provided by the respondents showed that 48.9% of the vessel operators resided in the northern section of the island. Another 28.5% lived in the western section, followed by 11.3% in the eastern section, and only 0.7% in the southern section. Over 10% lived further inland, away from the island's coastline.

In terms of primary ports, respondents listed the east coast as the most popular region (46%). Another 36.6% listed ports in the west coast (including the southwestern region of La Parguera) as their primary ports. In contrast to zip code results, the north coast accounted for only 10.8% of the ports used by vessel operators. Finally, 6.2% listed locations in the southern region as their primary ports.

Table 2: Vessel operator zip code and primary port

	West	South	East	North	Central
Zip code (n = 565)	28.5	0.7	11.3	48.9	10.4
Primary port (n = 546)	36.6	6.2	46.0	10.8	0.4

When regional zip codes were compared with primary ports, it was determined that there were distinct patterns in regional use. Those respondents who listed an eastern zip code invariably embarked from eastern ports. Similarly, those with western zip codes took almost 97% of their trips from a western port. However, those respondents who listed a northern or central (inland) zip code greatly favored eastern ports over other regional ports. Vessel operators with northern zip codes took 58.4% of their trips from an eastern port, compared to 23.4% who did so from a northern port. Similarly 55.4% of the respondents who listed central/inland zip codes favored an eastern port, followed by 23.2% who traveled to western ports.

Table 3: Vessel operator use of regional ports

	West	South	East	North	Central
West zip code (n = 160)	96.9	0.0	2.5	0.0	0.6
East zip code (n = 61)	0.0	0.0	100.0	0.0	0.0
North zip code (n = 269)	11.5	7.1	58.0	23.4	0.0
Central zip code (n = 56)	23.2	16.1	55.4	3.6	1.8

The results from Tables 2 and 3 show that there are two types of vessel operator populations on the island. The first type is that of a local/regional nature, where vessel operators embark from ports in their immediate region. In some cases, the ports may be considerable distances from their zip code, but are nevertheless in the same region. The second type is that of an extra-regional nature, where vessel operators reside either in the north (and most often in or around the San Juan metropolitan area) or in central/inland locations and either trailer or dock their vessels in predominantly eastern ports. In fact, the eastern region appears to be the most popular destination for vessel operators from local, northern, and central zip codes.

In terms of demographic and use patterns results, vessel operators demonstrated considerable expertise and reported taking frequent trips. On average, vessel operators were aged between 41-50 years old (mean = 3.92; SD = 1.16; n = 563; scale is 1 = less than 18 years old, and 6 = over 60 years old) and had owned or operated a vessel in Puerto Rico for between 11-15 years (mean = 3.72; SD = 1.67; n = 563; scale is 1 = less than 1 year, and 6 = more than 20 years). Use patterns as reported suggested considerable vessel activity, demonstrated by the 4-7 weekdays (mean = 2.12; SD = 1.72; n = 459; scale is 1 = 1-3 days, and 6 = 18-22 days) and 3.22 weekend days (SD = 1.98; n = 456) taken on average every month. Trip hours ranged from less than one hour to 72 hours, with the average trip lasting 4.92 hours (SD = 5.95; n = 544); 96% of the sample took trips that lasted less than 10 hours, with 60% of the respondents taking trips of between 1-6 hours. Finally, as related to capacity issues, vessel operators reported taking trips with multiple passengers. The average number of passengers (including operator) on a typical trip was 3.85 (SD = 1.48; n = 562). Over 70% took three or fewer passengers, with only 2% taking trips with seven or more persons. Smaller parties were also less common, with boat trips consisting of a single person accounting for only 1.4% of the sample.

When considered on a regional port basis, there were few differences found between respondents and their trip profiles in western, eastern, and northern ports[2]. Vessel operators in western ports tended to be a bit older than their eastern and northern counterparts, whereas eastern port respondents held the most experience, and tended to take the highest number of trips and passengers. Finally, trips from northern ports were slightly longer than those from the other ports.

[2] A total of 31 respondents were identified using southern ports (including Guayama, Jobos, Ponce, and Salinas) but were not analyzed as a separate region in part due to the small sample size (n = 31), the data collection areas (which were located in western, eastern, and northern vessel registration offices), and the trip patterns from southern ports (which tended to be mostly local and did not affect the natural reserves considered in the project).

Table 4: Vessel operator demographic profiles and trip patterns

	Total	Western ports	Eastern ports	Northern ports
Age	3.92 (1.16) n = 563	4.02 (1.25) n = 199	3.90 (1.17) n = 252	3.70 (1.15) n = 64
Years boating	3.72 (1.67) n = 563	3.70 (1.71) n = 199	3.84 (1.65) n = 251	3.52 (1.58) n = 65
Week days/month	2.12 (1.72) n = 459	2.10 (1.44) n = 173	2.14 (1.69) n = 204	2.05 (1.47) n = 47
Weekend days/month	3.22(1.98) n = 456	3.15 (2.02) n = 164	3.25 (1.97) n = 207	3.25 (2.01) n = 48
Trip duration (hours)	4.92 (5.95) n = 544	4.84 (3.80) n = 195	4.78 (6.74) n = 239	5.02 (2.76) n = 64
Passengers	3.85 (1.48) n = 562	3.91 (1.47) n = 198	4.00 (1.50) n = 251	3.27 (1.24) n = 65

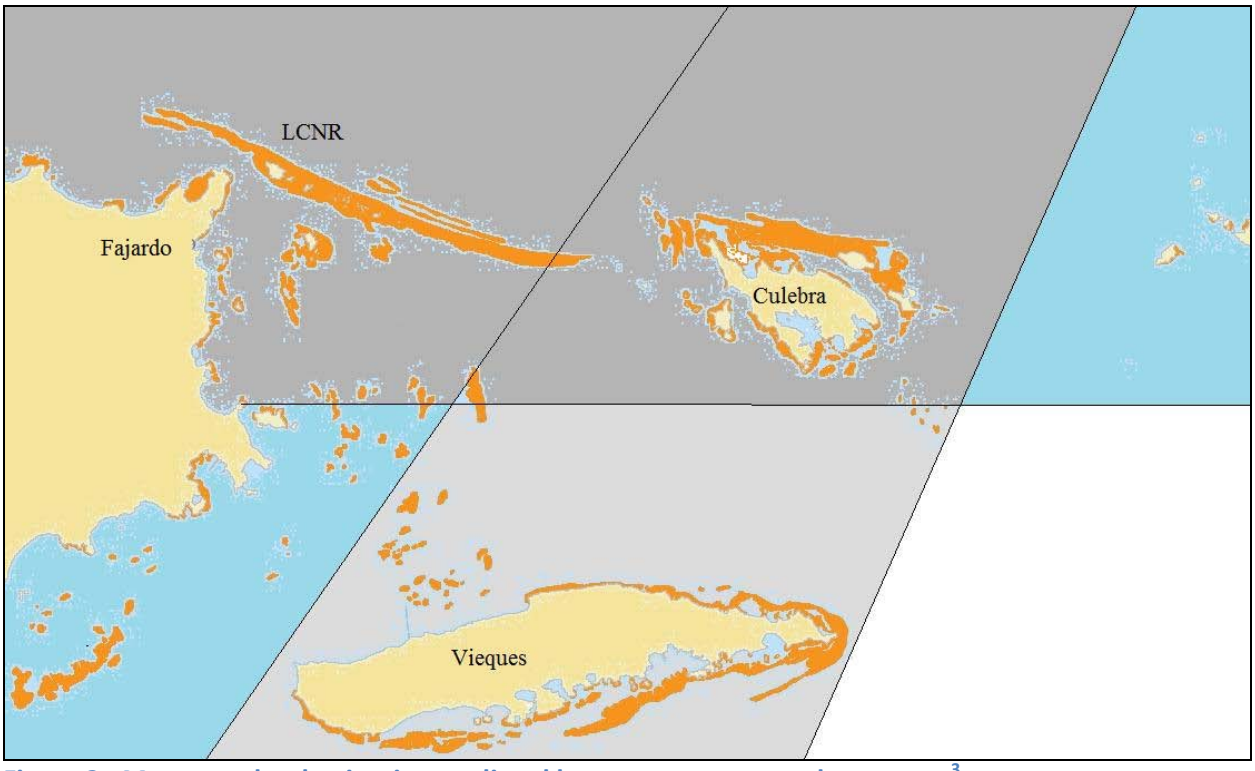
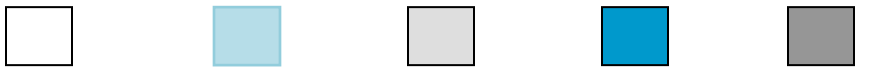


Figure 2: Most popular destinations as listed by eastern port vessel operators[3]



[3] Map generated using GIS application on Reef Base, depicting the eastern segment of Puerto Rico (land in yellow) and its coral reefs (in orange). URL: reefgis.reefbase.org/.

As shown in Figure 2, use within the eastern ports focused primarily in eastern destinations, of which Culebra and adjacent islands (ex. Culebrita) were the most popular; in fact, over a third, or 36.1%, of the 313 responses for most frequent destination listed Culebra or Culebrita. The second most popular destination among respondents comprised the islands in the LCNR, which accounted for 33.1% of the responses. Thus, just under a third of the vessel operators considered the islands of Icacos, Palomino, and Palominito as their most frequent destinations. Vieques, although popular at 19.8%, nevertheless was not as frequently visited as Culebra to the north and LCNR to the northwest. When respondents listed a location in Vieques, they generally identified Punta Arenas (the beach at the western end of Vieques, which is also known as Green Beach and which has a sandy bottom to allow for anchoring). Fewer respondents, or 3.5%, listed southeastern parts of the east coast (including Isla Piñeros, Palmas del Mar, and other locations) as frequent destinations. While Luquillo, Fajardo, and Ceiba in the northeast did comprise a majority of the ports identified for the east coast, and thus may have biased the use patterns to the north of the region, it is also clear from the extensive use of the islands of Culebra and Vieques that the use patterns identified may be indicative of the port-destination linkages for the coast. Moreover, when the subsample of southeastern ports is considered, 67% of the 21 most frequent destinations were identified as Vieques, followed by Culebra at 19.1%. Only 9.5% listed southeastern coastal areas as primary destinations.

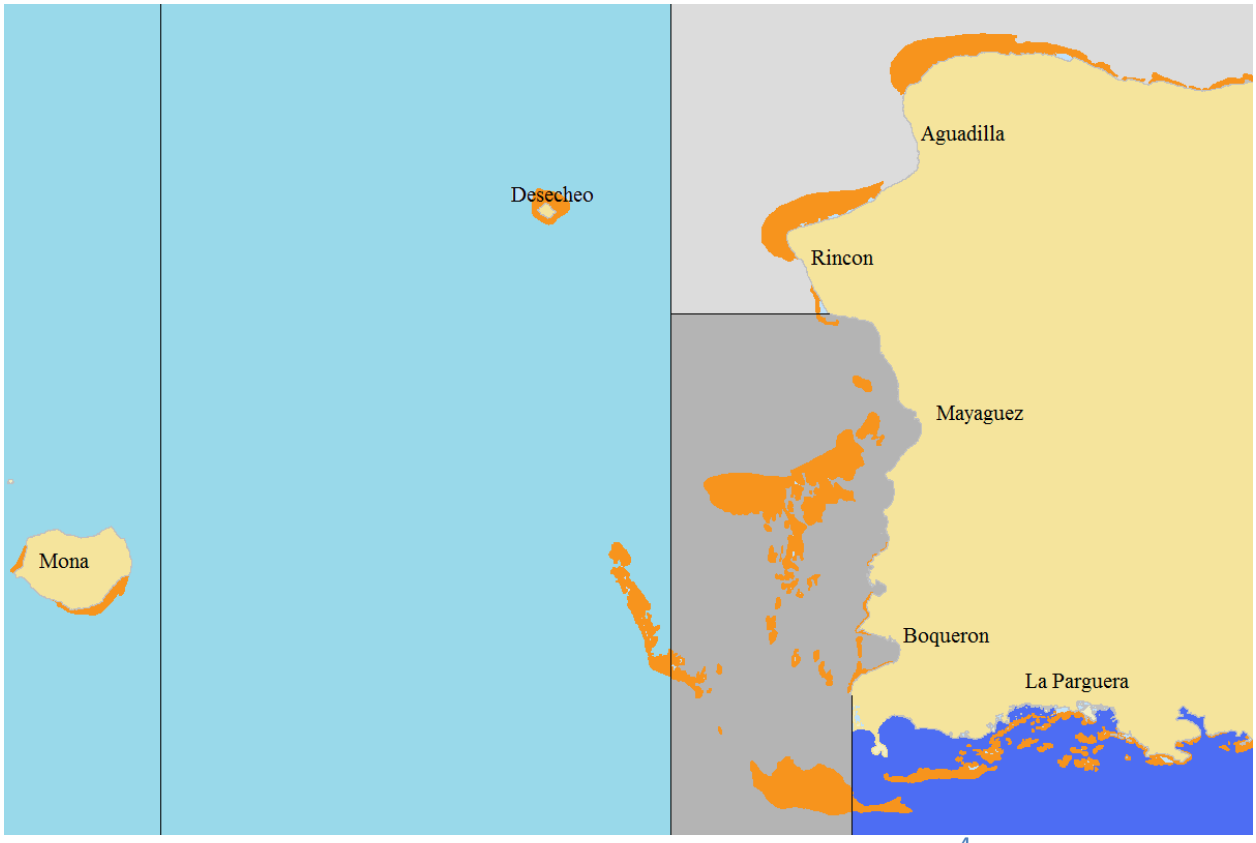
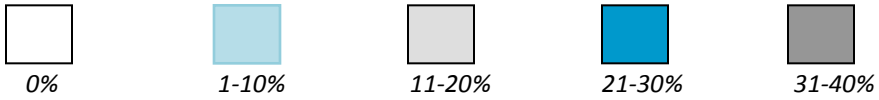


Figure 3: Most popular destinations as listed by western port vessel operators[4]



As shown in Figure 3, in the west coast, use was spread out across three main areas: the northwest, from Rincon to Aguadilla; the south from Mayaguez to Boqueron; and southwest, from La Parguera to Guanica. Most respondents identified the coastal region between Mayaguez to the south as their most frequently visited area, at 34.7% (Combate was listed by 18.2%). La Parguera was also a very important destination, and it led all other locations at 25%; altogether, respondents listed southwestern sites 27.6% of the time. Fewer responses identified sites in the northwest, which is likely a combination of higher survey totals from Mayaguez and areas south and the tendency of vessel operators to take trips to the southern parts of the west coast; 43% of the responses for most popular destinations listed by vessel operators using ports north of Mayaguez were in the central and southern parts of the western coast (i.e. Mayaguez to La Parguera). Fewer vessel operators from the west coast considered the islands of Desecheo (6.8%) and Mona (6.0%) as their most frequent destinations, most likely due to the islands' distances from the coast.

When asked about the amount of space afforded by the sites in which they recreate (Table 5), vessel operators on average believed that the conditions were normal (mean = 2.94; SD = 0.97; scale is 1 = very

[4] Map generated using GIS application on Reef Base, depicting the western segment of Puerto Rico (land in yellow) and its coral reefs (in orange). URL: reefgis.reefbase.org/.

crowded and 5 = not crowded at all). More respondents, however, believed that conditions were crowded (25.4%) than those who did not (20.1%). The views on space were generally consistent across the three regions.

Vessel operators stated that they saw an average of between 6-10 and 11-15 other vessels each trip (mean = 2.78; SD = 1.97; scale is 1 = 1-5 vessels and 7 = over 30 vessels), and that they would tolerate only a few more than 11-15 vessels before changing sites (mean = 3.11; SD = 1.92). There were significant regional differences in both the number of vessels seen on a typical trip and the number of vessels tolerated before respondents reported changing their sites. Vessel operators from eastern ports saw the most vessels on average each trip, or just over 11-15 vessels, compared to operators from northern ports who saw closer to 6-10 vessels per trip. The western ports were as crowded as eastern ports. Also, respondents from western ports required the highest increase in the number of vessels (mean = 3.39; SD = 1.79) before changing sites; this is to be contrasted with operators in northern ports who could tolerate a significantly lower number of vessels before changing sites. Views on crowding conditions may in part be influenced by the overall vessel traffic in each region; thus, vessel operators in eastern and western ports may have become more tolerant of higher densities of vessels than their counterparts in northern ports. Also, it is important to note that in each region, vessel operators claimed that they would switch sites if conditions changed by an average of 2.5 vessels or less. Thus, in each region, vessel operators believed that conditions are close to their tolerance levels. This is to be contrasted with the respondents' views on crowding, where the sample believed that conditions were normal. It could be that vessel operators perceive the amount of space as different than overall vessel densities, and that the former may be more a measure of being able to conduct one's activities whereas vessel density may present issues of safety and tranquility.

Table 5: Vessel operator perceptions on crowding conditions

	Total	Western ports	Eastern ports	Northern ports
Amount of space	2.94 (0.97) n = 437	3.00 (1.15) n = 199	2.93 (0.80) n = 148	3.09 (1.09) n = 64
Number of vessels seen on a typical trip	2.78 (1.97)^{A} n = 435	2.90 (2.06)^{B} n = 199	3.03 (2.02)^{C} n = 153	2.14 (1.62)^{ABC} n = 64
Number of vessels tolerated before changing site	3.11 (1.92) n = 435	3.20 (2.06) n = 199	3.39 (1.79)^{A} n = 146	2.59 (1.61)^{A} n = 64

*The superscripts A, B, and C denote means that are statistically different at the 5% level, where means with the same letter superscript are statistically different.

In terms of activities in which vessel operators reported participating, the most popular ones included a land-based component (Table 6). These consisted of visiting beaches (mean = 2.51; SD = 1.61; scale is 1 = always and 5 = never) and keys (mean = 2.51; SD = 1.48). More traditional activities, including cruising (mean = 2.71; SD = 1.69) and swimming (mean = 3.14; SD = 1.64), were less popular, with respondents stating that on average they participated in these activities during half of their trips. Also, diving (mean = 4.52; SD = 0.91) and snorkeling (mean = 3.79; SD = 1.35) were also not popular. Consumptive activities were not frequently practiced. In fact, while respondents listed occasionally line fishing (mean = 3.65; SD = 1.48) on average, spear fishing was among the least popular of all activities (mean = 4.73; SD = 0.67).

There were several regional differences in activities, with the eastern region showing significant higher frequencies of activities such as snorkeling, swimming, cruising, and visiting beaches. These differences varied across the entire sample or individual regions, depending on the activity. For instance, respondents using eastern ports were more likely to participate in snorkeling, compared to the entire sample and the respondents from the other two regions. Similarly, vessel operators in the eastern region visited beaches more frequently than the entire sample and their regional counterparts. For other activities, such as swimming and cruising, respondents from the eastern ports were more frequent participants than operators from one or both of the other regional subsamples. These results suggest a different activity profile for vessel operators (and their passengers) in the eastern region than in the two regions. The activities relate both to land-based activities (i.e. visiting beaches on islands that can be accessed by vessels) and water-based recreation, including snorkeling and swimming. These differences are likely in part due to the physical nature and geography of the eastern coast, which tends to have calmer waters (especially in the summer months) and hosts several vessel-based destinations in the form of the larger two islands of Vieques and Culebra and the smaller islands of the LCNR and southeast coast.

Table 6: Vessel operator water-based activities

	Total	Western ports	Eastern ports	Northern ports
Line fishing	3.65 (1.48) n = 565	3.56 (1.48) n = 200	3.72 (1.45) n = 252	3.46 (1.67) n = 65
Spear fishing	4.73 (0.67) n = 565	4.73 (0.66) n = 200	4.71 (0.72) n = 252	4.66 (0.71) n = 65
Diving	4.52 (0.91) n = 565	4.51 (0.95) n = 200	4.48 (0.90) n = 252	4.54 (0.94) n = 65
Snorkeling	3.79 (1.35)^{A} n = 565	3.95 (1.31)^{B} n = 200	3.55 (1.35)^{ABC} n = 252	4.15 (1.27)^{AC} n = 65
Swimming	3.14 (1.64) n = 565	3.31 (1.60)^{A} n = 200	2.93 (1.62)^{A} n = 252	3.09 (1.74) n = 65
Water skiing	4.65 (0.84) n = 565	4.63 (0.85) n = 200	4.66 (0.83) n = 252	4.66 (0.87) n = 65
Cruising	2.71 (1.69) n = 565	2.77 (1.67)^{A} n = 200	2.50 (1.65)^{AB} n = 252	3.14 (1.77)^{B} n = 65
Visiting beaches	2.51 (1.61)^{A} n = 565	2.70 (1.62)^{B} n = 200	2.25 (1.54)^{ABC} n = 252	2.88 (1.71)^{C} n = 65
Visiting keys	2.51 (1.49) n = 381	2.40 (1.43) n = 140	2.21 (1.30) n = 164	2.62 (1.47) n = 65

*The superscripts A, B, and C denote means that are statistically different at the 5% level, where means with the same letter superscript are statistically different.

Finally, the vessel operators stated their preferences for capacity-based management alternatives, consisting of daily vessel limits in areas, limits determined by permits or licenses, limits by mooring buoys, and the designation of no-access or no-anchoring zones. As shown in Table 7, the respondents favored managing use by having limits on the number of mooring buoys in a given area (mean = 2.99; SD = 1.71; scale is 1 = strongly favor and 5 = strongly oppose). The least preferred strategy was that of restricting use by licenses or permits (mean = 3.98; SD = 1.43), which many vessel operators argued would amount to an additional registration fee and hence a financial burden. Generally, respondents from northern ports held the most favorable view on management alternatives, apart from no-access or

no-anchoring zones, for which western port operators showed the highest level of support. Because all other forms of management alternative involved either restricted access (in the form of vessel limits or zoning) or increased payments (i.e. additional licenses or permits for access) and represent untried approaches, it appears that vessel operators gravitated towards the mooring buoy alternative, with which they have experience in areas like the LCNR and LPNCR and which is maintained by management agencies.

Table 7: Vessel operator views on management options to control access

	Total	Western ports	Eastern ports	Northern ports
Vessel daily limits	3.83 (1.48) n = 463	3.88 (1.47) n = 199	3.89 (1.42) n = 158	3.55 (1.52) n = 64
Access licenses or permits	3.98 (1.43) n = 463	3.96 (1.40) n = 199	4.11 (1.33) n = 158	3.78 (1.62) n = 64
Limits by mooring buoys	2.99 (1.71) n = 463	3.06 (1.70) n = 199	2.96 (1.72) n = 158	2.75 (1.71) n = 64
No-access or no-anchoring zones	3.33 (1.69) n = 463	3.27 (1.70) n = 199	3.41 (1.67) n = 158	3.35 (1.67) n = 64

Vessel operator survey study recommendations

The following recommendations are based on the major findings described in the methodology and results sections of the vessel operator survey study and are provided in the context of both future studies to better characterize the vessel operator population and to determine the stakeholder group's preferences for management alternatives to maintain the biophysical and social integrity of NRs.

Need to develop an island-wide vessel operator survey program

An island-wide survey program with vessel operators can provide important information that can be used for disparate activities such as determining the need for marinas, boat slips, and other infrastructure, identifying dominant use patterns from individual ports as a means by which to improve boating safety and reduce vessel traffic, characterizing use preferences based on region, and quantifying use within protected and other sensitive areas (i.e. creating a port-destination linkage network).

The costs of the effort would be limited to data entry, periodic data analysis (statistical and GIS), and supplies. The current effort has shown that operators can complete self-administered surveys and provide considerable information related to use profiles, use patterns, activities, and management preferences. Moreover, the survey methodology has demonstrated that it is a cost-effective means by which to gather large datasets that can have diverse applications. Finally, while the survey designed in this project focused on issues concerning crowding and related management alternatives, future efforts could be modified to collect the aforementioned information and use add-on questions when a particular management question is to be addressed.

Need for a better understanding of port-destination linkage networks

While the present study did identify general port-destination linkage networks, a larger survey program (as described in the previous recommendation) is needed to better understand the various traffic patterns from popular ports. In some cases, such as Fajardo and other northeastern ports, the traffic patterns are clear, in that use from those ports is largely local and extends to the eastern islands of Culebra and Vieques; however, a larger study evaluating effort from inland areas and from southern ports (both not considered in the present study) would elucidate vessel traffic patterns that in turn could reveal trends in resource use and areas visited.

Need to monitor vessel operators' views on crowding

The present study determined that vessel operators believed that while conditions were 'normal' in terms of crowding, they would nevertheless only tolerate an average of 2.5 more vessels in the areas where they recreate. This discrepancy may be a result of the operators' interpretation of both questions, where the former (concerning crowding) may have been perceived to be related to the space available for recreation, whereas the latter (concerning vessel density) may have been perceived to concern safety issues. In both measures, however, it appears that vessel operators felt that the areas they visit are reaching full utilization, where conditions are 'normal' versus providing sufficient space or all the space they need, and where vessel densities are approaching tolerance limits.

The measurements concerning crowding did shift according to the amount of pre-existing crowding (ex. eastern port operators reported viewing more vessels than their counterparts in other regions and were willing to tolerate more vessels than the rest of the sample); thus, it is recommended that operators' views on crowding be monitored to determine whether there is a change in perceptions on crowding and tolerance of vessel density, or if the crowding baseline is shifted where higher vessel densities simply increase the tolerance level.

Need to determine vessel operators' preference on management approaches

This study presented four management alternatives focused on capacity issues to the vessel operator sample, but future efforts should focus on a suite on management questions as needed to determine the stakeholders' views on such issues. This could be done for particular ports where a management decision is to be made using the add-on questions as described in the recommendation for a vessel operator survey program. The approach could be targeted according to the sample required, based on overall vessel operator use patterns.

As an example, if there were a management proposal to consider the implementation of a national marine sanctuary in eastern Puerto Rico, then a suitable study using the vessel operator study would be to provide the San Juan and Puerto del Rey vessel registration offices with an add-on survey that serves as an educational tool (i.e. informs respondents of the proposed action), obtains use information specific to the management option (ex. uses within the proposed area, traffic patterns, seasonal densities, etc.), and obtains views on the acceptability of the management option.

Similarly, a vessel operator survey program sets up the framework via which to address a multitude of management issues as targeted to only those operators who have been shown to be affected by the

issues. The fact that the program itself can build on existing infrastructure and would allow surveys to be compartmentalized such as add-on units can be implemented only when and where needed greatly enhances the efficacy of the approach.

Puerto Mosquito Bay Natural Reserve (PMBNR) case study

The results for the PMBNR were obtained from an earlier study conducted by Shivlani (2007) as part of a project concerning stakeholder and visitor preferences for marine protected areas in Vieques. As stated in the methodology, the information was gathered in a year-long (2004-05) visitor intercept survey study, and via water operator field surveys and interest group interviews. Results from published literature were also used to develop this case study.

The PMBNR is located in the central portion of southern Vieques (Figure 4). It is abutted to the west by Sun Bay, which is operated by PR National Parks and is a multiple use beach and recreation area, and to the east by the Vieques National Wildlife Refuge (VNWR) (Figure 5). The US Fish and Wildlife Service administers the VNWR which, unlike the PMBNR, is only a terrestrial protected area (FWS, 2003). The reserve was established on July 1, 1989, and it consists of the terrestrial component from the main road (route 997) to the mangrove fringe surrounding the bay, as well as the bay and waters extending out of the bay to the Commonwealth of Puerto Rico maritime boundary. The PMBNR, like the other reserves considered as part of this project, is administered by the DRNA (Aguilar-Perrera et al., 2006).

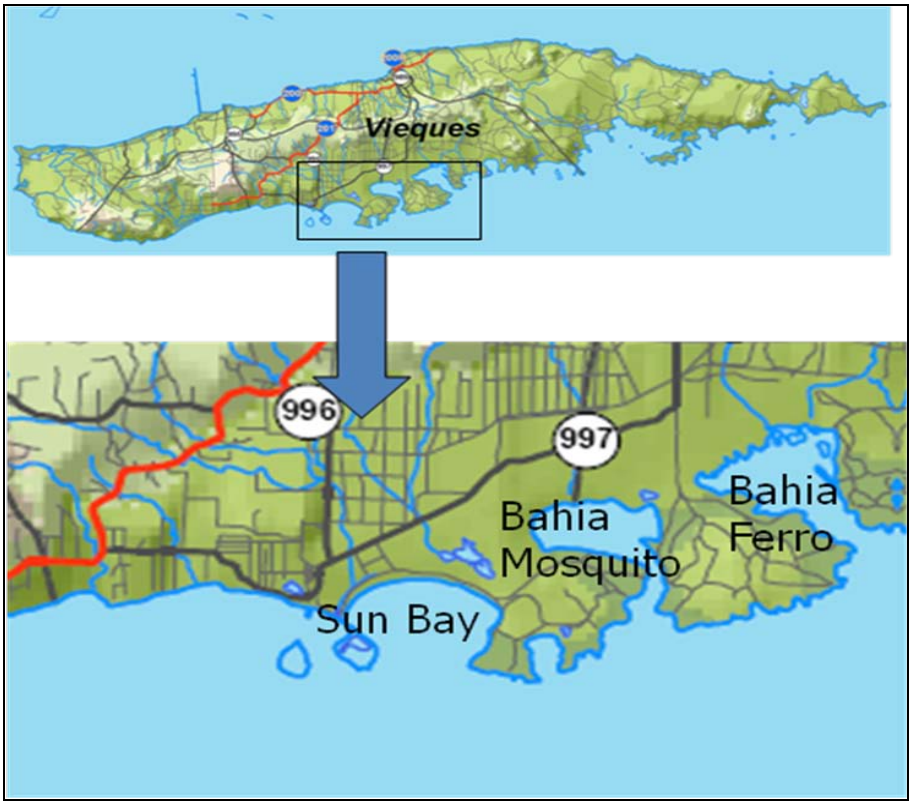


Figure 4: PMBNR region in context

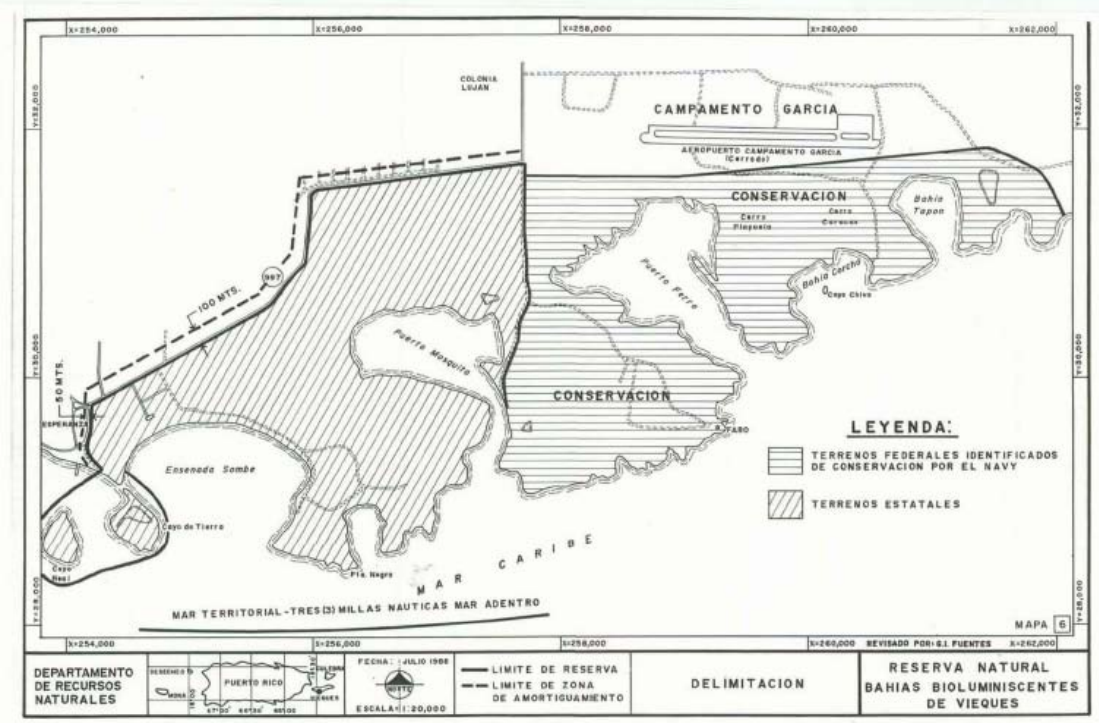


Figure 5: PBMNR area and boundaries (source: DRNA, 2008)

The PMBNR contains one of three well-known bioluminescent bays in Puerto Rico (the other two are located in La Parguera in southwestern Puerto Rico and Fajardo in northeastern Puerto Rico), which attracts considerable ecotourism. Because the bay is located adjacent to and downstream from areas now undergoing development (see Figure 5 showing the PMBNR watershed), there is concern that anthropogenic impacts may affect the quality of the bioluminescence and effectively degrade a major tourist attraction (Gasparich, 2007; B. Baker, Vieques Conservation and Historical Trust, personal communication, December 12, 2005; M. Martin, Vieques Conservation and Historical Trust, personal communication).

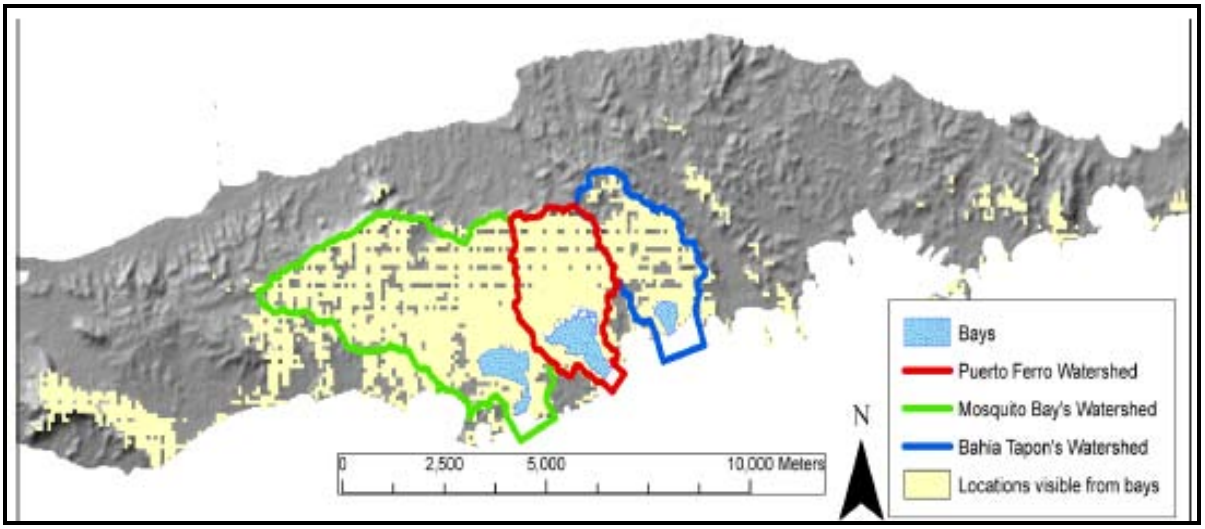


Figure 6: PMBNR watershed and light pollution (source: Tainer, 2007)

As shown in Figure 6, the PMBNR extends north and northwest to the upland developments and town of Esperanza (to the west). Clearly, the bay and its water quality are dependent on the development practices within its watershed. Moreover, light pollution emanating from urbanization leads to a diminished tourist experience, as the bioluminescence effect is most dramatic in a dark setting. Another potential impact from development, but which has not been realized (DRNA, 2008; Gasparich, 2007; Tainer, 2007), is increased sedimentation leading to a filling in of the bay and the resulting decrease in dinoflagellate population and related bioluminescence; however, unless the reserve is effectively protected against this and the aforementioned impacts, the bay may experience a future decline (Gasparich, 2007; Tainer, 2007).

As part of the project that evaluated stakeholder and visitor preferences for marine protected areas (Shivlani, 2007), a visitor field intercept survey was implemented in late 2004. Via a survey questionnaire, visitors were asked questions concerning their trip experience to Vieques, including their trip profiles, activities in which they participated, and their preference for a marine protected area on the island. Surveys were conducted while visitors waited to board the ferry back to Fajardo or at the airport while embarking on their return flight. The survey effort commenced in December 2004 and ended in November 2006, and a total of 306 surveys were completed in a total of 48 session (two weekday and two weekend days per month).

Demographic results showed that over half of the sample was from Puerto Rico, and 47.6% were non Puerto Rican visitors, which included 6.7% foreign visitors. Most visitors, or 63.7%, stayed overnight, and the average length of stay was 3.8 days. Just over 52% of the visitors had not been to Vieques before, and 2.6% reported the main reason for their visit being the PMBNR bioluminescent bay (compared to 36% and 30.1% who listed beaches and relaxation, respectively, as the main reason for their visit).

While on the island, 47% of the visitors took a trip to the PMBNR bioluminescent bay. This represented the second most popular activity, exceeded only by beach visits (95% visitation rate), and it surpassed all other coastal and marine activities (Figure 7). Moreover, in terms of ranking, respondents rated PMBNR higher than any other visitor experience; the average rating was 4.82 on a scale from 1-5, where 1 is poor and 5 is excellent. Based in part on their positive experience with PMBNR and Vieques' other coastal and marine resources, visitors were generally very satisfied with their trip (mean = 4.75; scale where 1 = poor and 5 = excellent) and very likely to return (mean = 4.51; scale where 1 = very unlikely and 5 = very likely).

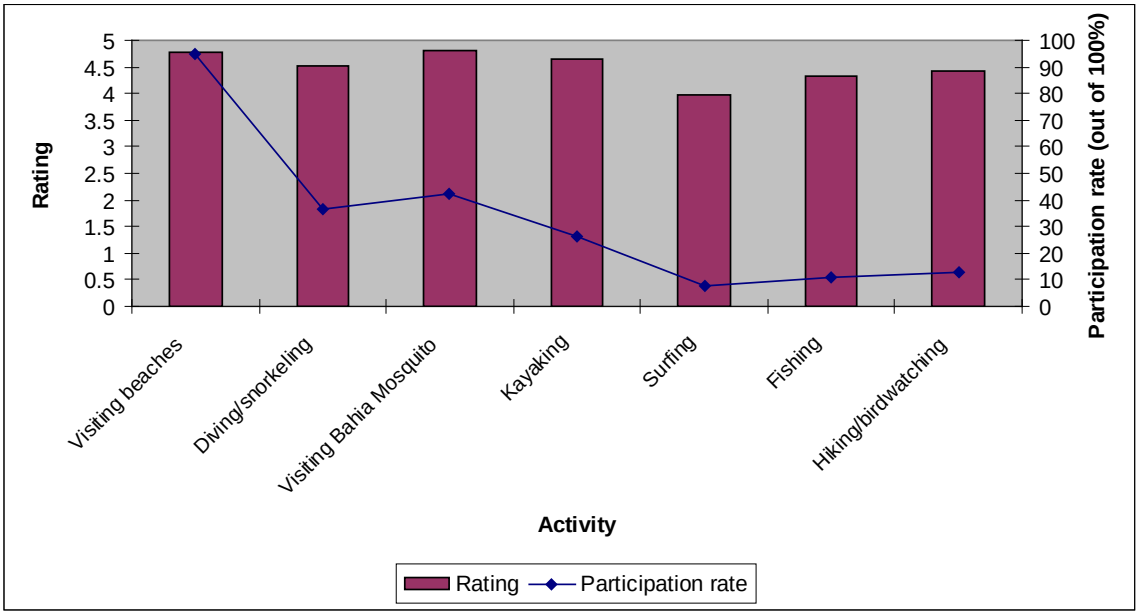


Figure 7: Vieques activity participation rate and ranking (source: Shivlani, 2007b)

Visitors were greatly in favor of establishing a marine reserve or MPA around Vieques, with 94.1% supporting the establishment and only 3.6% opposed (Figure 8). Among the activities that respondents argued should be disallowed within such an MPA were commercial fishing (61%) and development (59%). Fewer than 30% and less than 5% argued that recreational fishing and diving and snorkeling represented incompatible uses in an MPA, respectively. Less than 40% of the visitors interviewed identified an area to be set aside as an MPA, but as shown in Figure 7, the southern part of Vieques (where the PMBNR is located) was among the more favored sites. Also, 20% of those who identified an area that they would like to receive additional protection was PMBNR.

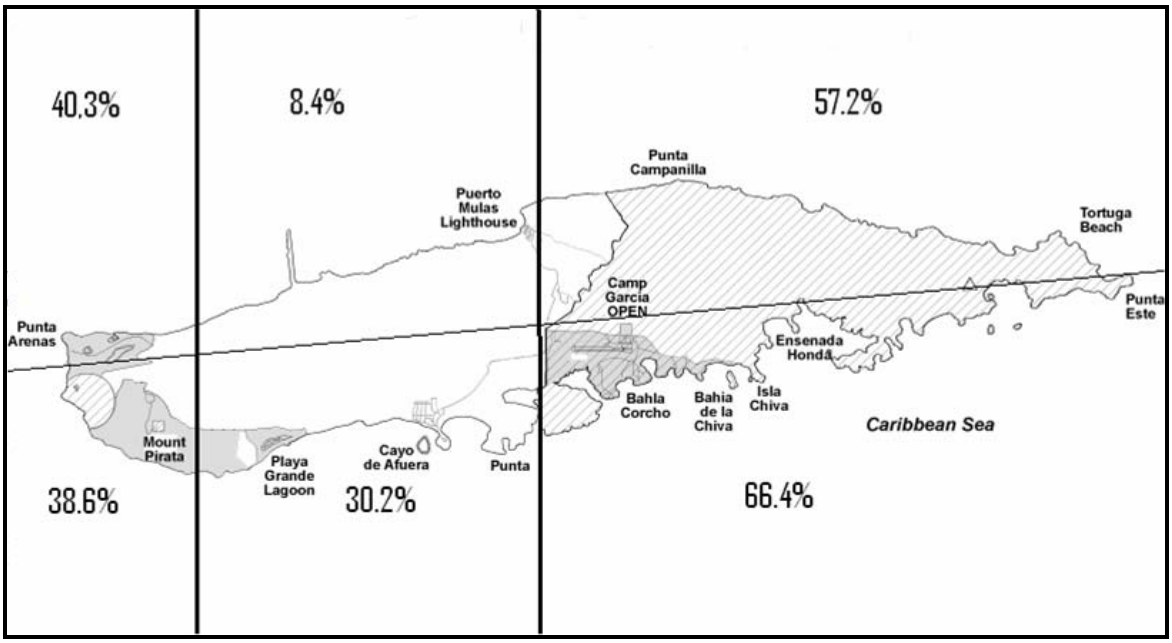


Figure 8: Location for a Vieques MPA as supported by visitors (source: Shivlani, 2007b)

The visitor results demonstrated the strong ties that a healthy environment has to tourism in Vieques. Respondents rated the environmental resources on the island in good to excellent conditions, ranking PMBNR as the most pristine of those resources. Also, the results showed the wariness with which visitors perceived development, which they ranked behind commercial fishing as an incompatible activity around an MPA.

Stakeholder and interest groups, especially conservation group members, strongly seconded the visitors' views on the importance of a healthy resource base on the island and warned against the threat of development and its impacts on that resource quality. As determined by field-based surveys, commercial fishers who fished on the south side of the island reported using PMBNR mainly as a safe harbor during hurricanes; otherwise, they did not use the bay water for commercial fishing activities (apart from occasional bait fishing). For the commercial fishers, the bay's waters were simply not as productive as waters outside the bay, and they served more as nursery areas than fishing grounds. In terms of protection, the commercial fishers interviewed believed that while the US Navy posed the greatest threat until its departure in 2003, it was development that presented the most difficult challenge to the island's resources.

Water-based operators, who were also surveyed in person, were represented by a variety of operation types, including kayak, sailboat, pleasure craft, and diving operations. Six of the operators interviewed were concessionaires who were permitted to take trips into the PMBNR's bioluminescent bay. Five operated kayak tours and one used an electric boat. The kayak operators were allowed to take out a maximum of 30 kayakers per day to the bay, and they used an entrance from the main road through a dirt road that provided access to the bay. The electric boat operation had permission to use another entrance (through Sun Bay to the west) in order to access the bay. Some stakeholder groups complained that traffic through the access roads had exacerbated runoff into the bay and thereby increased sedimentation and decreased the average depth. Other stakeholders believed that visitation rates had led to a decline in the concentration of dinoflagellates. However, results from Gasparich (2007) and Tainer (2007) suggest that there have been no significant anthropogenic impacts on the bay's dinoflagellate population and depth, respectively; however, both authors also warn that development needs to be addressed as part of a land use plan due in part to the bay's extensive watershed. A majority of the water-based operators themselves believed that development is the main, long-term threat to the island's sustainability and the factor that most needs to be addressed. With respect to PMBNR, several operators also argued in favor on controlling light pollution, which they identifying as emanating from an upland development overlooking the bay.

The stakeholder group consisting of hospitality centers (hotels, motels, and guest houses) was also interviewed in person, and respondents provided information on guest statistics and views on the linkages between the island's environment and tourism. While visitation rates were not always provided, over half of the centers interviewed stated that the number of their guest had either increased (42%) or remained the same over the past three years, or since when the US Navy departed. Also, it appears that return visitation was important, as 39% of the respondents reported hosting return guests. Hospitality centers believed that Vieques' coastal and marine environment was largely responsible for the island's tourism, and almost all respondents believed that their guests visit Vieques to recreate on the local beaches. Over 67% reported that an important guest activity was visiting PMBNR. Over a third of the hospitality centers, or 37%, believed that development was the main stressor to Vieques' coastal and marine environment, followed by pollution (21%) and fisheries (11%).

Also, 68% agreed that if development were to result in a diminished resource base, it would have a negative impact on tourism (and hence their business operations).

Finally, the study used a series of semi-structured interviews to interview key informants from members of local conservation groups. The general consensus among interviewees was that there was a need to better protect the island's coastal and marine resources from development and, in particular, resort-style development. Some of the persons interviewed also argued that immediate action was necessary to protect the PMBNR from increased sedimentation resulting from upland development and overuse and from light pollution. Other interviewees believed that unless development is managed as part of a comprehensive land use and social policy, Vieques would turn into another Caribbean resort destination, and that the development impacts would affect not only the local environment but also disenfranchise local communities.

The results from the case study demonstrate that stakeholder and interest groups in Vieques considered capacity issues and limits of acceptable change on a watershed scale, and that their concerns were not driven as much by current use as they were by future changes in visitation rates and in the **type** of visitors. That is, while certain groups felt that use within PMBNR should be modified using best management practices (ex. reducing run-off by restricting the number of vehicles allowed through the access road into the bay), this was not cited as a primary concern. Neither was the amount of total use in the bay, which DRNA controls by capping the number of concessionaires and setting daily limits on users. Instead, all stakeholder and interest groups identified development as the stressor that needs to be addressed to allow for the sustainability of the bay and, indeed, the island's coastal and marine resources. Both stakeholders and visitors identified a direct link between the health of the island's natural resources and the viability of its tourism industry.

Recommendations

While the following recommendations relate specifically to the PMBNR, all but especially the final recommendation refer to the need to incorporate factors other than resource trends and use patterns (i.e. incorporate historical events and those these may have shaped opinions on resource management) in the management process.

Limits of acceptable change or capacity issues may be scalar and not necessarily related to user densities and direct impacts

A case study such as the one presented for PMBNR demonstrates the scalar nature of limits of acceptable change and carrying capacity, as well as how limits are interpreted in terms of the quality of change. For the stakeholders and interest groups on Vieques, change from an ecotourism economy to a resort economy was largely unacceptable, as were the perceived impacts that would accompany such a transformation. For resources such as PMBNR that rely on a healthy watershed, reduced runoff, and less light pollution, development represented the preeminent threat to the bay's sustainability.

There is a need to understand inter-stakeholder dynamics and stakeholder-environment dynamics in considering capacity issues

The different stakeholders in Vieques had largely convergent goals and this allowed in part for a shared vision on sustainability. That is, commercial fishers, water-based operators, hospitality centers, and interest groups had few direct conflicts, either in terms of use or access, and all had a stake in increased protection from environmental degradation. Also, because various stakeholders relied considerably on a healthy environment for economic reasons, their views on development were shaped in part by the impacts that development would have on the viability of their operations (i.e. lowered visitation rates to degraded environments).

Political and social history should be considered in areas to better appreciate stakeholder views on capacity and limits of acceptable change

The US Navy's presence on the island of Vieques from the 1940s to the early 2000s united various stakeholder groups against a perceived common threat (McCaffrey, 2002). With the exit of the US Navy, the threat was shifted to the Fish and Wildlife Service, which was perceived by many stakeholders (and especially residents) to have taken the US Navy's place. It could be that mentality that has allowed stakeholders to perceive development as another "outside" threat and a change that is unacceptable.

Luis Peña Channel No-take Natural Reserve (LPCNR)

The LPCNR is a small (4.8 square kilometer) no-fishing reserve designated in June 11, 1999 by the Governor of Puerto Rico's Planning Board, which selected the area in part for the ecological and economic value of its coral reefs and related resources (CIEL, 2008a). The reserve contains a high diversity of species, including rich benthic habitats consisting of sea grasses, hardbottom, and corals. Mangroves, though present in the reserve, are scarce and found only in a few locations (due to the mostly marine nature of the zone). See Figure 9 for reserve boundaries.

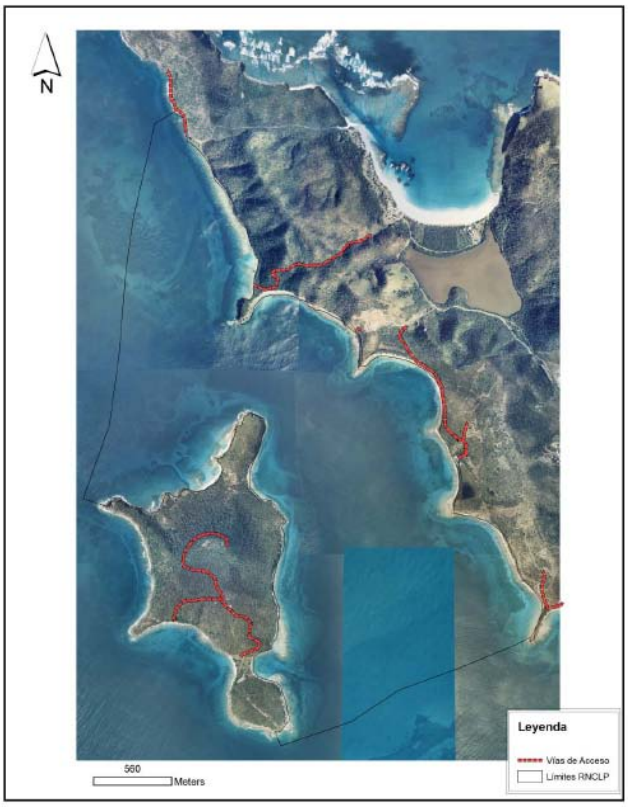


Figure 9: LPCNR boundaries and access routes (source: CIEL, 2008a)

In terms of uses of the reserve prior to its closure, most of the area on Cayo Luis Peña and on the eastern coast of Culebra facing the reserve was used by the US Navy from the early 1900s to the mid-1970s for bombing activities, related military exercises, and installations (CIEL, 2008a). Wherever compatible with US Navy activities, recreational and fishing uses also occurred within now reserve boundaries. Since the departure of the US Navy in 1975, Culebra followed a path towards tourism as the island's mainstay economy. While commercial fishing was and remains an important cultural enterprise, its economic presence as measured by the number of participants and landings has experienced a declining trend. There is fishing pressure that emanates from the southern island of Vieques (CIEL, 2008a; Shivlani, 2007b) and from the mainland (Agar et al., 2008), and the CIEL report (2008a) identifies considerable illegal fishing within reserve boundaries. In fact, overfishing is considered one of the major threats facing the reserve, along with eutrophication, unexploded ordinance, development, and anchor damage and other vessel impacts (CIEL, 2008a).

The LPCNR management plan identified a total of 41 uses within the reserve, consisting of a variety of allowed and illegal uses. Among the former, the plan lists recreational activities such as boating, diving, snorkeling, swimming, kayaking, photography, and cruising, among others. These non-consumptive activities comprise a majority of the uses consistent with reserve objectives. There also exist other activities that occur on the land side of the reserve, especially in Flamenco Beach, which is one of Puerto Rico's most popular (and heavily visited, on a seasonal basis) beaches (CIEL, 2008a). Flamenco Beach and other areas provide land-based access to the reserve. Otherwise, the reserve can only be accessed by vessel (see Figure 9). While there are 19 mooring buoys to accommodate vessels, the LPCNR management plan notes that there remains a problem with anchoring on hard bottom and corals (CIEL, 2008a).

The LPCNR case study focused on the allowed uses to determine the number of visitors and visitor use/density conditions within the reserve, as provided by water-based operators who reported taking trips to the reserve. A previous pilot study conducted with visitors in Flamenco Beach was also used to incorporate land-based use information (Loftin, 2004). It should be noted that the purpose of the case study was less to determine the total number of users within the reserve than it was to obtain qualitative information on the (a) present conditions within the reserve as perceived by water-based operators and (b) identify issues that may need to be addressed by management.

Loftin (2004) used a field intercept survey approach to interview departing passengers on the Culebra to Fajardo ferry and at the Culebra airport. The survey questionnaire contained questions on visitor demographics, use profiles, and willingness to pay for the protection and maintenance of the LPCNR. While only 11.9% of the 217 visitors surveyed reported having entered the LPCNR, a majority of the sample (or 96%) stated that they would be willing to pay a daily access fee to enter the reserve if the funds were used specifically for management and conservation purposes. The average willingness to pay was higher among the subsample that entered the LPCNR ($4.58) than it was for the subsample that did not enter the reserve ($3.73). Also, visitors ranked the resource conditions (including beaches, coral reefs, water quality, and other coastal and marine resources) as good to excellent, and 59% of the respondents stated that they were very likely to return for another visit.

The visitor study results show strong linkages between the quality of tourists' experience with the condition of Culebra's coastal and marine resources. Moreover, the contingent valuation question determined a willingness on a large majority of the visitors to pay for the marine reserve. Taken together, it is likely that overall resource conditions may have affected the respondents' support to contribute for the maintenance and conservation of LPCNR, although most may not have experienced the reserve firsthand.

In 2007-08, a total of eight interviews were conducted with water-based operators to evaluate stakeholder views on the use patterns and current conditions in the LPCNR. Additional information was provided by commercial fisher interviews that were used to determine the abundance of fishery resources within the reserve.

Six of the eight operators were located in Culebra, and the other two offered trips from Fajardo/Ceiba. Of the eight operations, three were snorkel and/or excursion tours, three were dive/snorkel operators, one was a kayak tour operator, and one was a water taxi. One of the operators on Culebra took trips in the vicinity of the reserve but did not use the reserve. Among the other seven operator, use within the reserve varied considerably, ranging from 2-100% (and the average was 63%). Similarly, the number of clients taken out per trip varied as well, with excursion trips accommodating up to 30 passengers to smaller vessels taking no more than six passengers. The average capacity was 11.4 passengers per operation.

Most operators stated that they took trips to the LPCNR because of its healthy corals and fish abundance. Several added that the reserve had some of the best coral reefs in the region, and that its reserve status had afforded at least some protection to fish species (notwithstanding the rampant poaching which most operators also acknowledged occurs within the reserve). Asked if there had been any changes in the amount of use in the reserve, all except one operator believed that use had remained constant; the operator who disagreed actually believed that use had **declined** since the

increase in fuel prices. Some respondents felt that while use had not changed much, there was a seasonal increase in the number of users (especially private vessels) in summer months.

Operators were less in agreement over existing conditions within the reserve. While most agreed that corals and other benthic habitats within the reserve were in good condition, others warned that they had witnessed increasing damage to corals. The main reasons given for the damage were vessels anchoring on coral, illegal fishing, and pollution generated from vessels and land-based pollution. However, most operators believed that the reserve offered sufficient space, had ample mooring buoys, and did not require greater enforcement. Two respondents did call for having a few more mooring buoys, but none of the operators believed that the current array was insufficient.

Finally, operators had differing views on how enforcement should function within the reserve. For those operators who believed that the reserve could not be protected from poaching activities, enforcement was not considered important. Such operators called more for an education approach, and some of these respondents added that they educate their customers during their trips and have incorporated best management practices in their operations (ex. warning snorkelers and divers not to touch coral, collecting all trash, etc.). Conversely, those operators who believed that the reserve could achieve its no-take objective were more in favor of active enforcement. Answers provided to the question concerning the need for more marine reserves in Culebra reinforced the split in views on enforcement efficacy among operators. Those in favor of enforcement agreed that there should be more reserves, even though one agreed that reserves may not work due to the preponderance of illegal fishing in the region. Those against having more reserves claimed that instead of designating more no-fishing zones, management actions should focus on educating local stakeholders on the importance and value of marine reserves.

Recommendations

As previously stated, the LPCNR case study focused solely on water-based operators who are allowed to enter the reserve for nonconsumptive, recreational activities. As a stakeholder group that has extensive experience with the reserve, the LPCNR operators were considered the appropriate set of users via which to understand present conditions and resource trends in the reserve (see similar work conducted with water-based operators in Key West, Florida (Thomas J. Murray & Associates, 2006). Because of the relatively small size of the reserve, and the limited extent of users as measured by the number of operators, a study of this scale could be easily accomplished.

LPCNR water-based operators serve as an excellent source of local knowledge and should be further engaged in the marine reserve management process

The water-based operators are very knowledgeable about conditions and trends in the LPCNR and are the only group allowed to enter the reserve. As a stakeholder group that stands to benefit from having the reserve achieve its objectives, water-based operators should be engaged in monitoring activities, including the collection of basic biophysical and use data. These could be formalized in a survey instrument, data log notebook, or other reporting format that could allow for the monitoring of changes in use patterns in the reserve. Similar work has been conducted with dive operators in southwestern Puerto Rico, showing how dive operations can provide important, local ecological knowledge (Rivera Miranda, 2007).

There is a need to establish baseline conditions of use within the reserve, including use by private vessels and shore-based users

While the case study was able to determine water-operator use profiles, it is important that similar profiles be developed for the other stakeholders that utilize the reserve. Apart from providing a baseline against which future conditions and trends may be compared, the profiles may used to measure visitor satisfaction ratings (Leeworthy and Wiley, 1996). Effectively, the baseline can serve as a benchmark for the present views on capacity, providing an objective measure on the number of users recreating in the reserve, their perceptions on resource conditions, and satisfaction with their overall experience, among others. Updated baselines could be determined to evaluate how changes in reserve performance (ex. greater species diversity, larger fish, etc.) correlate to visitor totals, uses in the reserve, and user perceptions (see Shivlani et al., 2008 for a baseline replication study of stakeholders in the Florida Keys National Marine Sanctuary).

The LPCNR and the LCNR water-based operator groups could assist in comparative studies on the benefits of multiple use and no-fishing zones

The dive and snorkeling sites in the LCNR and the LPCNR provide an excellent opportunity via which to conduct myriad studies comparing the benefits of the different types of zones, and these could be done in collaboration with the water-based operator industry (see Letson et al., 2005, for a collaborative dive-operator study evaluating the effectiveness of no-fishing zones in the Lower Florida Keys). Among these studies, water-based operators could monitor the views of their customers on the crowding conditions in each area, thereby generating trend lines on levels of use and perceived limits of acceptable levels of use. Other studies could include the measurement of diver and snorkeler impacts of corals and related habitats using well-established methodologies in projects conducted in the Caribbean and elsewhere; results from such studies could be used to establish ranges of user totals in minimizing recreation-based damage.

La Cordillera Natural Reserve (LCNR)

The LCNR, officially known as La Reserva Natural Arrecifes de Cordillera, was established in January 22, 1980, by the Puerto Rico Planning Board (CEA, 2007). The reserve is mostly marine and accessible only by water, and it covers approximately 120 square kilometers in a mosaic of islands, keys, and coral reefs northwest of Fajardo in northeastern Puerto Rico (CEA, 2007). Excluded from the designation are the islands of Lobos and Palomino, the latter of which is a very popular beach destination for guests staying at the Hotel Conquistador in Fajardo. The reserve boasts a variety of coastal and marine habitats. Keys include dry forest and mangrove lagoons, nearshore areas including sandy habitats, sea grasses, and patch corals, and coral reefs and associated habitats are distributed around the reserve (see Figure 10 for a map of the reserve and its boundaries).

Figure 10: La Cordillera NR (source: http://amp-pr.org/blog/?p=46)

The reserve is a multiple-use area and hosts a variety of activities, including recreational uses such as snorkeling, diving, fishing, windsurfing, waterskiing, cruising, and beach visitation, and commercial fishing using gears such as traps, lines, nets, and SCUBA (CEA, 2007). Fishers using the reserve are to abide by general fishery regulations and are not subject to LCNR-specific rules. The draft LCNR management plan identified main fishing grounds located to the north of Cayo Icacos, but it also determined that fishing does occur within the reserve (CEA, 2007). In terms of recreational uses, the most heavily visited areas are Cayos Icacos, Palomino, and Palominito. While use occurs year-round, it tends to peak for local tourists from April to August and during the weekend days. Non-resident tourists tend to visit the region more frequently from November to March (CEA, 2007). Recreational users access the reserve on their own vessels, chartered vessels, or commercial vessels. While the LCNR require concessionaires to hold a permit (the cost of which includes a 15% per head tax to DRNA), a few commercial fishers take out passengers in illegal charters (CEA, 2007).

According to the LCNR management plan, the main threats facing the reserve consist of sedimentation impacts from coastal construction on the mainland, proposals to develop Cayos Lobos and Palomino, recreation based impacts including vessel groundings, anchor damage, and propeller scarring, water quality impacts from vessels and land-based sources (especially marinas), and a lack of enforcement (CEA, 2007). To these must be included the potential impact of commercial and recreational fishing on the integrity of the coral reef ecosystem and thus the achievement of the reserve's objective to conserve and manage its natural resources.

The LCNR case study was developed using two main sources of primary data: (1) water-based operator in-person interviews; and (2) registered vessel operator surveys. The former were conducted from 2007-08, and the latter was part of the larger vessel operator survey effort discussed earlier. However,

the vessel operator surveys that the Puerto del Rey vessel registration office administered from September 2007 – March 2008 differed from the other general vessel operator survey in that it contained a map specific to the Puerto Rico east coast and included questions on uses within the LCNR.

LCNR water-based operator study

In 2007, a total of 25 water-based operations, consisting of dive operations, multiple-activity day trip operations, were identified for the northeastern coast of Puerto Rico (Luquillo to Ceiba). This list was generated using an internet-based search, using brochures and other promotional material, and working with the LCNR manager and other officials. Of the 25 operators, five had sold out or were no longer taking trips. Another two stated that their main activities were located to the north of the LCNR and were thus not included. Only one operation refused to participate in the study. Finally, the aforementioned Conquistador hotel, which operates ferries to and from Palomino Island, was not considered as a water-based operator for the study because of the island is not part of the reserve[5]. So, in total, 16 of the 17 operators eligible for the study were interviewed in 2007-08. The surveys were mostly conducted in person, unless the respondent was otherwise unavailable or requested a phone survey.

Questions in the surveys asked about the operator's experience in the LCNR, vessel characteristics, trip frequencies and use patterns, areas visited, views on acceptable numbers of users by use type, perceptions on changes in user densities, and changes in resource quality. Operators were also asked to identify high use areas or areas that represent conflicts, as well as to rank conflicts with their own and other user groups.

The experience or years taking trips in the LCNR, as reported by the operators, varied greatly. Some had been in operation for 25 or more years, whereas others had only recently started. The average tenure in the LCNR was 12.0 years (SD = 10.2; n = 13), which was over three years less than the total experience reported by the respondents (mean = 15.3 years; SD = 11.1; n = 13). The average tenure does demonstrate over a decade of trips in the LCNR, denoting considerable experience taking trips in the reserve.

Operators owned an average of 1.63 vessels (SD = 0.95; n = 16), with most operations owning a single vessel. In multiple-vessel operations, respondents stated that not all vessels took trips to the LCNR. Thus, where an operation owned one large vessel (capacity greater than 20 passengers) and one or more smaller vessels (capacity less than 20 passengers), the former vessel would be used for the typical half to full-day trip in LCNR, while the smaller vessels may be used to fishing charters, day trips to Culebra or Vieques, or even extended day trips.

The average number of passengers that could be taken in the 27 vessels listed was 22.1 (SD = 19.7), with larger catamarans able to accommodate between 45-80 passengers. If only the larger vessels (capacity

[5] In a follow-up discussion with the LCNR manager (H.Horta, LCNR manager, personal communication, June 20, 2008), who explained that while Palomino Island is private, its beaches are part of the reserve and thus should be included as part of a broader evaluation; thus, it is recommended that a short survey be conducted with the Hotel Conquistador officials in charge of the ferry service to determine overall use as measure by average daily loads, types of activities, and views on resource conditions.

greater than 20 passengers) are considered, which are almost exclusively used for LCNR trips, then the average number of passengers per vessel was 40.2 (SD = 16.0; n = 12).

Vessels generally had a lower capacity for divers than for snorkelers. That is, fewer divers than snorkelers could be taken per trip. While all dive operations stated that they took both dive and snorkel trips, the catamaran operators and mixed charters usually only offered snorkel trips. The average number of divers taken out by the six operations that reported taking dive trips was 13.3 divers/trip (SD = 9.16), compared to the 28.6 snorkelers/trip (SD = 22.7) taken by 14 operations.

Most of the operations surveyed offered more than one type of activity, often as part of the same trip. The larger catamarans took mixed-activity trips which commenced with a cruise to one of the LCNR islands, followed by snorkeling and a beach visit. The smaller charters offered either fishing charters or mixed-activity trips, with the latter being taken to more remote areas within and outside the LCNR. Transportation services did offer on occasion snorkeling gear, but their main role was to transport passengers to and from island beaches. Finally, dive operations generally only offered dive trips, on which snorkelers were sometimes allowed. Of the four operation types, dive operations were the most specialized and (as will be discussed further) the most sensitive to crowding conditions. Figure 11 shows the percentages of activity type available in LCNR.

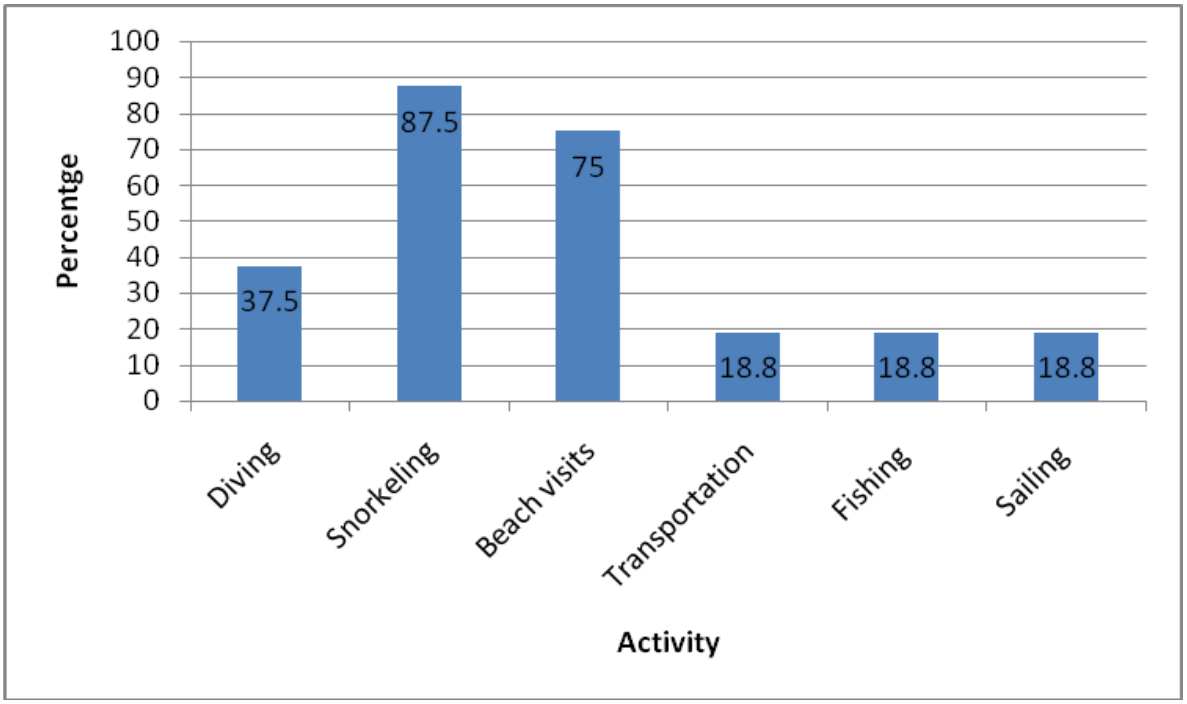


Figure 11: Activity types and percentages in LCNR

Operators took an average of 370.0 trips per year (SD = 340.8; n = 15); however, there was considerable variation in the number of trips, due in part to the nature of the operation (ex. whether it took scheduled trips or if it were a charter) and the number of vessels used in the operation. Also, it should be noted that the average includes all trips and not only those specific to the LCNR. While operators were not asked to estimate the total number of trips taken to the LCNR, based on use areas operators identified in maps, it is estimated that over 95% of all trips were taken within the reserve.

The average number of visitors taken per trip was 16.8 (SD = 12.5; n = 14). Dive trips consisted of fewer clients than snorkel or mixed-activity trips, where the former averaged 10.2 divers (SD = 6.23; n = 5) per trip and the latter averaged 16.8 passengers (SD = 12.5; n = 14) per trip. Only 20% of the operators reported taking consumptive trips in the LCNR, and these were exclusively fishing charters. Most operators did not allow fishing on their trips, and several added that they also did not permit shell collection. Overall, the average percentage of consumptive trips taken in the reserve was 3.0% (SD = 7.02; n = 15). This finding suggests that water-based operators do not rely on charter fishing **within** the LCNR; as stated above, fishing charters do engage in consumptive activities, but they do so mostly to the north of the LCNR (this information was provided by both respondents in this case study and reported in the LCNR management plan (CEA, 2007)).

Operators provided their views on how the LCNR had changed over their tenure. The respondents believed that, on average, there had been an increase of over 100% in the number of commercial vessels (mean = 113.1%; SD = 131.2; n = 13), an increase of almost 150% in the number of private vessels (mean = 145.1%; SD = 132.3; n = 13), and an increase of 78.1% (SD = 116.1; n = 13) in the number of visitor. As previously stated, there were several operators who had been using the reserve for two decades or longer. Figure 12 shows the difference in views on reserve conditions based on the amount of time that respondents had been operating in the reserve. Effectively, operators' views on the increase in the number of commercial and private vessels and total visitors were directly related to the amount of time they had been operating in the reserve. For instance, operators with less than 10 years of experience in the reserve believed that the number of commercial vessels, private vessels, and visitors had increased by 68%, 97.5%, and 48.3% respectively. By contrast, those who had more than decade of experience operating in the reserve felt that commercial vessels had increased by 151%, recreational vessels by 186%, and visitors by 104%. Nevertheless, regardless of experience, both subsamples were in agreement that the increase in the private, or recreational, vessel sector had outpaced the commercial vessel and visitor growth in the reserve. Not all operators were able to comment on the changes in the number of divers and beach visitors, but the sample reported increases in both diver (41.0%; SD = 69.5; n = 10) and beach visitor (77.4%; SD = 120.1; n = 11) totals in the reserve over their tenure.

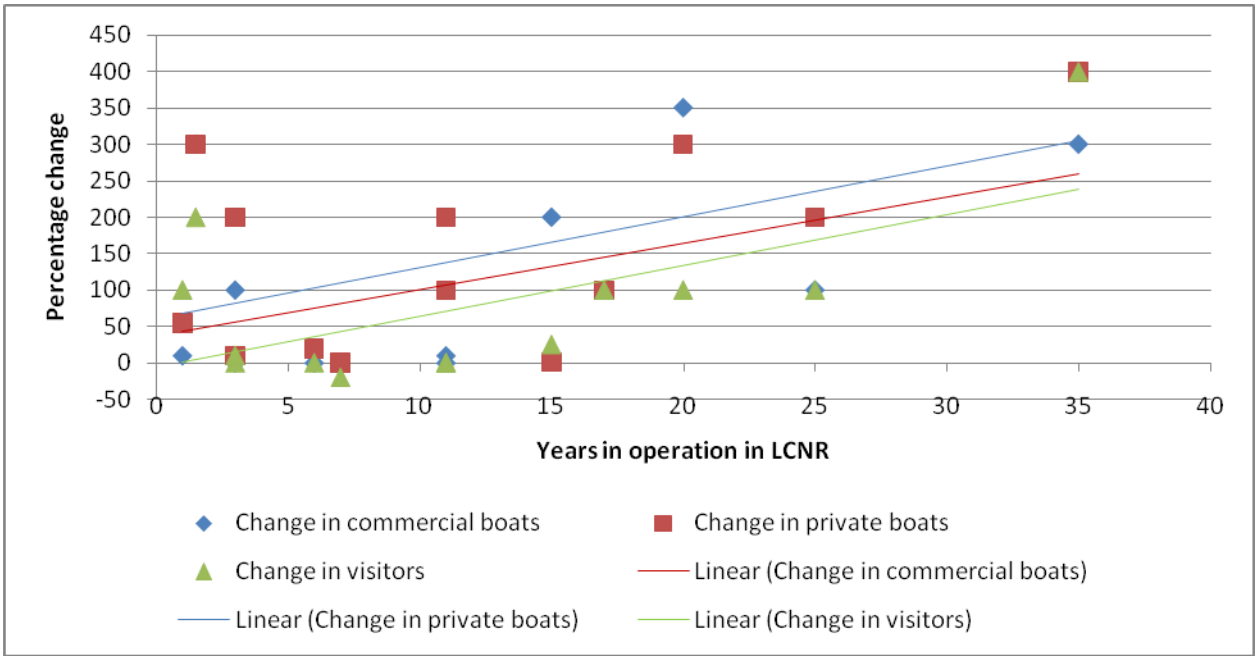


Figure 12: Perceived changes versus length of tenure in LCNR

Asked if they change location based on the number of users in a site, 33.3% of the 13 respondents stated that they always change their location. This total included several dive operations that, as previously stated, had a lower threshold than the other operator types for the number of users in a given area (mainly for safety issues). Another 41% stated they change their locations sometimes, and among these respondents, there were several larger vessel operators who added that the change would be made only if it were early in the day (ex. a morning trip), if the other large vessels were all in a given area, if they could not safely tie up to a mooring buoy, and if the weather permitted the change. Unlike the dive operators who have more options in selecting dive sites, catamaran operators are less able to switch sites. The itinerary and activities for most catamarans is similar in the LCNR. They cruise from one of two main ports in Fajardo/Ceiba (Villa Marina or Puerto del Rey) and head northeast to Cayo Icacos for snorkeling and beach visitation (arrow 1 in Figure 14). From there, they cruise east to Cayo Lobos (Arrow 2), after which they return to port (Arrow 4). If the wind is blowing from the south, the itinerary is shifted to the islands of Palomino and Palominito in the southern part of the reserve (Arrow 3). Thus, regardless of crowding conditions, catamaran operators may not always have the option of switching sites. Other factors that influence or otherwise limit catamaran use are the number of mooring buoys available at sites, safety conditions, travel speeds, and fuel costs. Together, these and the aforementioned factors effectively circumscribe catamaran use in the LCNR in a zone around the principal islands of Icacos, Lobos, Palomino, and Palominito.

Also, operators believed on average that 84 users (SD = 90.1; n = 10) is an acceptable amount to have in a site. Catamaran operators felt that the sites they visit would accommodate more users, due in part to the difference in areas visited by large vessel versus small vessel operators and relative vessel size (see Figure 13). Similarly, while on average the sample felt that sites could accommodate a maximum of 164 users (SD = 125.3; n = 11), which was about twice the acceptable total, there were differences among catamaran and smaller vessel operators (see Figure 12). Finally, the sample believed that the capacity of beach sites was on average almost three times greater than that of dive site, where the mean for the

maximum number of divers per site was 87.5 divers (SD = 68.4; n = 10) and visitors per beach site was 225.6 visitors (SD = 151.3; n = 9).

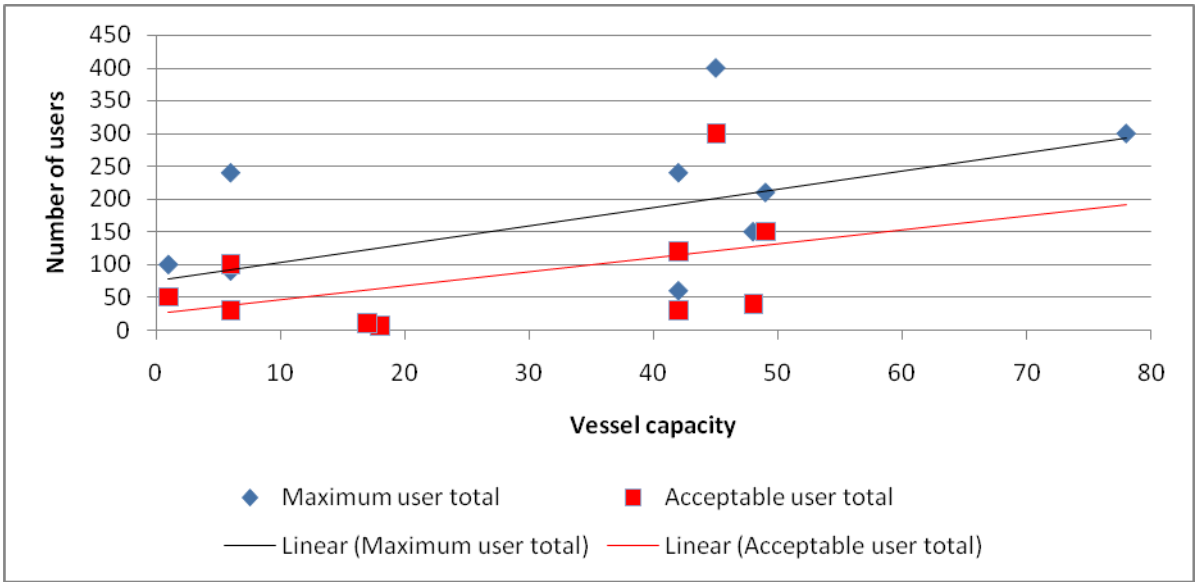


Figure 13: Number of users per site versus vessel capacity

In terms of user conflicts, which may be another measure of crowding conditions, the water-based operators reported few to no conflicts. On a scale from 1 to 4, where 1 represented strong conflict and 4 represented no conflict, the 13 respondents who answered these questions reported having no strong conflicts. For example, the average ranking for conflict with other concessionaires was 3.92 (SD = 0.28), and 3.35 (SD = 1.20) for recreational fishers. Rankings for recreational, and especially consumptive, divers (mean = 3.0; SD = 1.35) and recreational boaters (mean = 2.85; SD = 1.14) suggested higher levels of conflicts between operators and these user groups. Several operators complained that there is a need for boater education, as many of the private (recreational) vessel operators do not respect others and are a nuisance and even danger in the reserve. Others felt that consumptive divers sometimes undertake dangerous activities, such as spearfishing, near their clients and are otherwise disruptive (by not using dive flags, by encroaching into areas being utilized by operators, etc.).

Finally, when asked to compare changes to impact/resource conditions within the LCNR, on a scale from 1 to 5, where 1 represented improvement and 5 represented deterioration, 13 water-based operators felt that anchor damage (mean = 4.08; SD = 1.04), vessel damage to LCNR resources (mean = 4.0; SD = 0.95), and coral reef conditions (mean =3.92; SD = 1.19) had worsened the most of any impact/resource over the time that they had been operating in the reserve. The other impacts/resources were considered to have also worsened were fish abundances (mean = 3.54; SD = 1.26), water quality (mean = 3.23; SD = 0.73), and cleanliness (mean = 3.15; SD = 1.34). Importantly, none of the impacts/resources were measured to have improved (i.e. mean = 2.0-2.5), with only slight improvements in mangroves (mean =2.92; SD = 0.67), levels of user conflicts (mean = 2.92; SD = 0.86), and space for navigation (mean = 2.85; SD = 0.55). Effectively, all impacts/resources within the reserve had either worsened or remained the same over the tenure of the respondents, with key resources such as coral reefs and related resources having worsened over this time period.

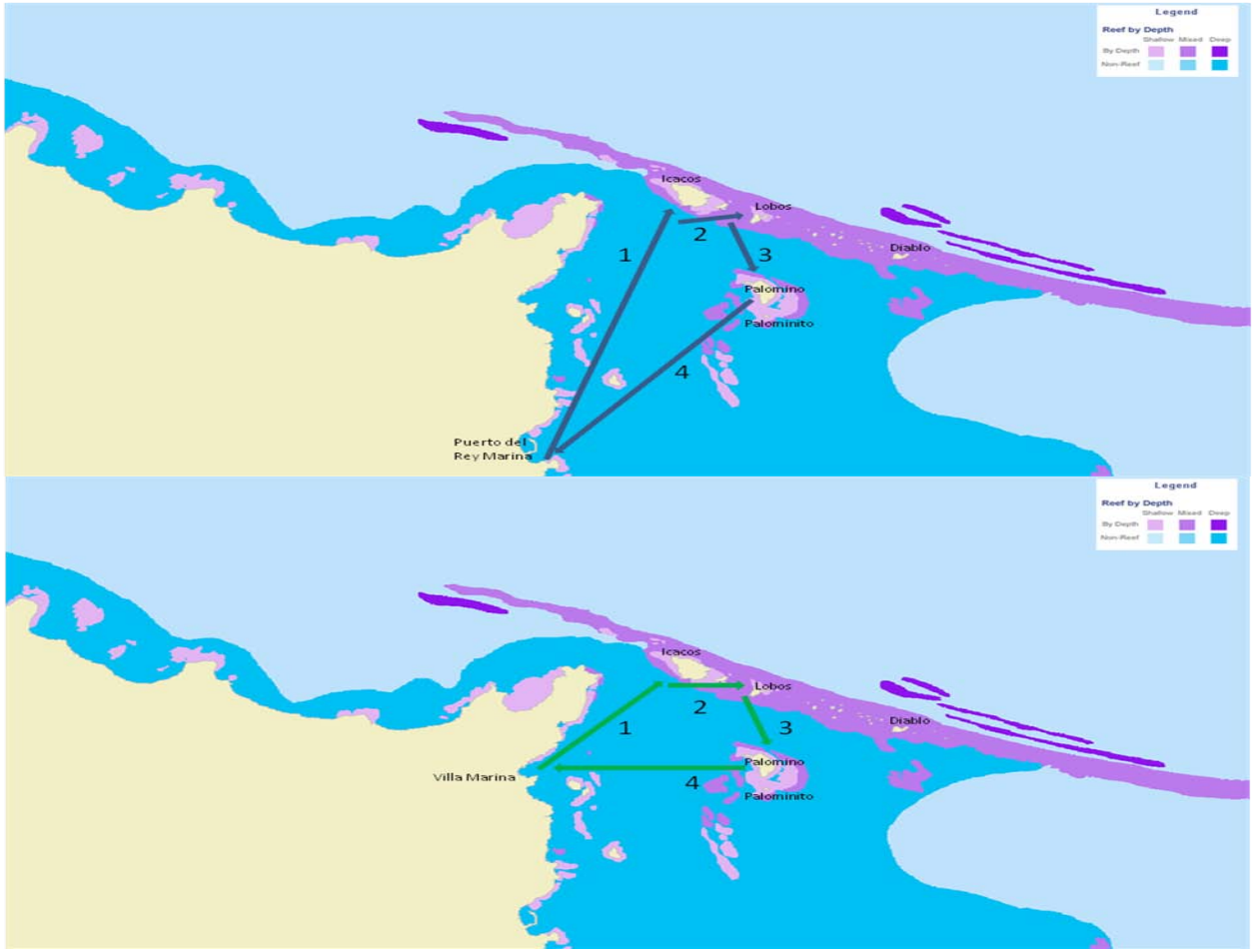


Figure 14: Catamaran use patterns in LCNR from the ports of Puerto del Rey and Villa Marina

LCNR registered vessel operator study

A total of 102 respondents filled out surveys from September 2007 to March 2008 in the Puerto del Rey vessel registration office. The vessel operator survey utilized was similar to that used for the other vessel registration offices except that it included questions on uses in the LCNR and used a map showing only the east coast of Puerto Rico and in particular the LCNR. Of the 102 respondents, 71.6% (n = 73) listed the LCNR as a primary destination or identified it as a destination on the use map. In terms of LCNR operator characteristics, the following results represent a subsample of the larger east coast vessel operator findings discussed in the vessel operator study discussion (section 3.1).

In terms of demographic characteristics, LCNR users were just between 41-50 years of age (mean = 4.19; SD = 1.09) and had operated a vessel for 11-15 years (mean = 4.10; SD = 1.6). The average age and experience for LCNR operators were both slightly higher than for the overall vessel operator sample. Compared to the average boating patterns among all other vessel operators surveyed, LCNR operators took slightly fewer weekday (mean = 2.09; SD = 1.52; n = 68) and weekend trips (mean = 2.97; SD =1.92; n = 65) which lasted 4.49 hours (SD = 2.57; n = 68); however, LCNR operators did take more passengers on average (mean = 4.10; SD = 1.70; n = 72) than did the full sample.

The most frequently conducted activities reported by LCNR operators were visiting beaches (mean = 2.56; SD = 1.66), cruising (mean = 2.90; SD = 1.73), visiting keys (mean = 3.10; SD = 1.67), swimming (mean = 3.23; 1.63), line fishing (mean = 3.29; SD = 1.55), and snorkeling (mean = 3.60; SD = 1.43). The activities in which LCNR operators least engaged were water skiing (mean = 4.74; SD = 0.80), spearfishing (mean = 4.67; SD = 0.90), and diving (mean = 4.51; SD = 0.93). It is interesting to note that activities such as snorkeling and visiting keys were less popular among LCNR operators than for the full sample, whereas LCNR operators on average participated more frequently in line fishing than did the full sample.

When asked about the LCNR, 64.4% of the respondents stated that they knew about the reserve before completing the survey. This finding suggests that over a third of the operators who stated using the LCNR were not aware of its protective status. When it is considered that over 67% of the operators reported to have visited the reserve in the previous year, it is clear that the reserve must be more actively promoted to increase user awareness. In terms of activities in which operators participate while in the reserve, the most popular of these were visiting beaches (50.7%), cruising (41.1%), snorkeling (39.8%), swimming (37.0%), and visiting keys (32.9%). While over a quarter of the respondents listed fishing (26.0%) as an activity, only 11% listed diving. When considered as a suite of activities, swimming, snorkeling, diving, and cruising were undertaken with an average of three or more other activities; by contrast, fishing and visiting beaches were undertaken with an average of fewer than three activities. This shows that fishing and beach visitation are less often components of multiple-activity trips in the LCNR and are more likely than the other activities to promote single-activity trips.

A large majority of the respondents, or 91.8%, reported having visited Palomino; 80.8% stated that they had visited Icacos. These two islands represented the most popular destinations in the LCNR (and were often identified in the use map, as discussed below). Among other LCNR destinations, 35.6% of the operators had visited Lobos, and only 20.6% had visited Diablos. Visitation appears to have been directly related to distance, as the islands closest to port (in this instance, the ports being considered are

those in the Fajardo area) were those that were most often visited, such that Diablos – which is the furthest of the four islands – was the least visited.

Figures 14-16 show the spatial use profiles of trips taken by recreational vessel operators from the combined ports of Fajardo and Ceiba (n = 74). As shown in Figure 14, 86.5% of the respondents listed the LCNR as a destination, compared for 66.2% and 64.9% who listed the islands of Culebra and Vieques, respectively. Within the LCNR, most operators identified specific islands as their most frequent destinations. These consisted of Palomino and Icacos, and this may be due in part to the fact that these two islands were identified by name in the survey map. In general, however, operators did not list trips to the eastern reefs (Hermanos, Bariles) in the LCNR. Fewer respondents taking trips from Fajardo listed Isla Piñero as a destination (10.8%), and more operators reported taking trips to the southeast than to the northeast.

Similarly, not all respondents who took trips to the islands of Culebra or Vieques identified specific locations. But among those who did, there were specific sites that were more important than others. Within Culebra, 18.9% of the trips listed by operators were taken to the Luis Peña No-take Channel Reserve, making it the most popular destination on the island (Figure 15). This finding is important to the previously discussed LPNCR case study, as it demonstrates the need to assess recreational vessel use within the reserve to determine operators' uses within the reserve and their perceptions on the reserve's effectiveness. Other areas in Culebra that were important for vessel operators included southern Culebra (the port of Dewey) and the islands of Culebrita and Cayo Norte.

The most popular destination for operators who identified specific locations within Vieques was Punta Arenas, or Green Beach, where 28.4% respondents listed taking a trip (Figure 16). Punta Arenas is popular because it offers anchorage and is located adjacent to a beach that is now part of the Vieques National Wildlife Refuge (FWS, 2003). Approximately one tenth of the subsample also identified locations in southern central Vieques (namely Esperanza, Sun Bay, and Puerto Mosquito Bay NR) and southeastern Vieques (from Ensenada Honda to the southeastern end of the island). Finally, fewer than 10% identified the northeastern side of the island and the town of Isabel II as destinations.

Among those operators who did not list Fajardo as a port, use patterns were more varied. Most of these operators embarked either from the two outer islands of Culebra or Vieques or from southern ports (Naguabo and ports to the south). The most popular destination was Vieques, identified by 68.4% of the 19 operators, followed by Culebra (52.4%), and areas south of Fajardo (26.3%). Importantly, only 21.1% listed the LCNR as a destination, suggesting that notwithstanding the small subsample, use patterns may be highly local in northeastern versus southeastern Puerto Rico and that a majority of effort in the LCNR may be derived from Fajardo and adjacent ports.

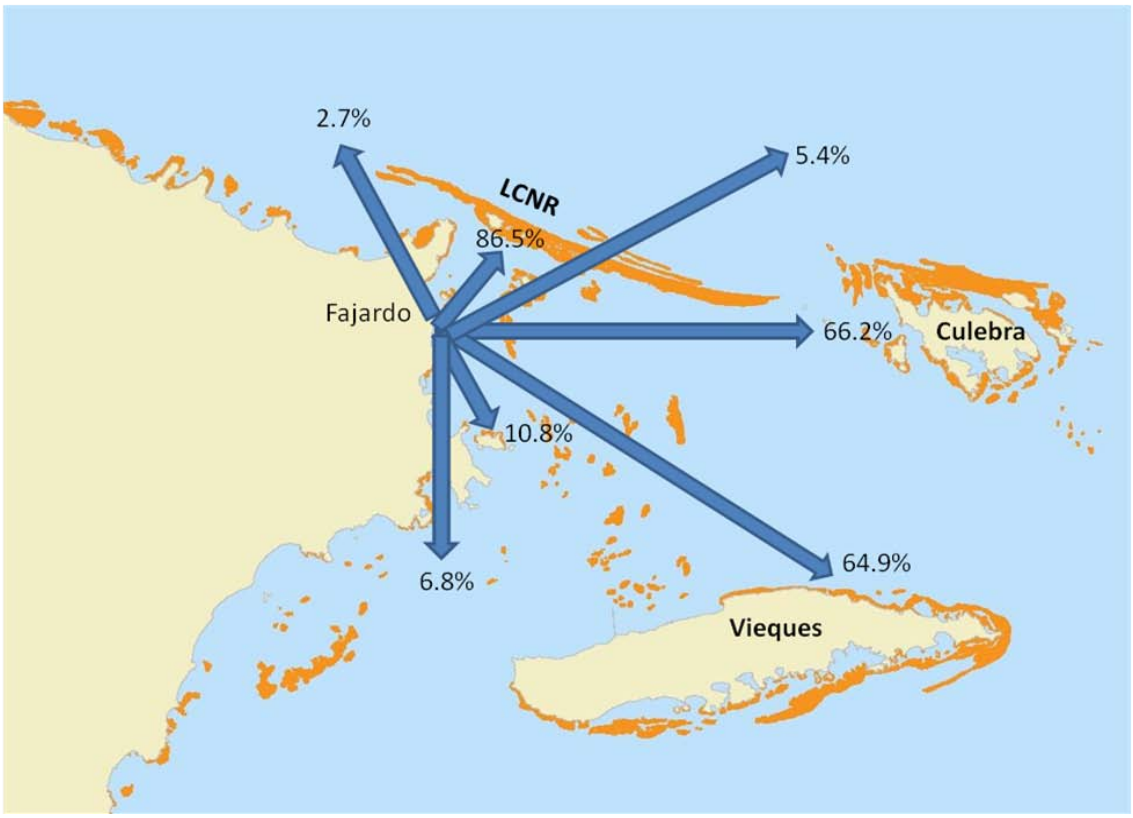


Figure 15: Recreational vessel use patterns via Fajardo in eastern Puerto Rico

Figure 16: Recreational vessel use patterns via Fajardo in Culebra

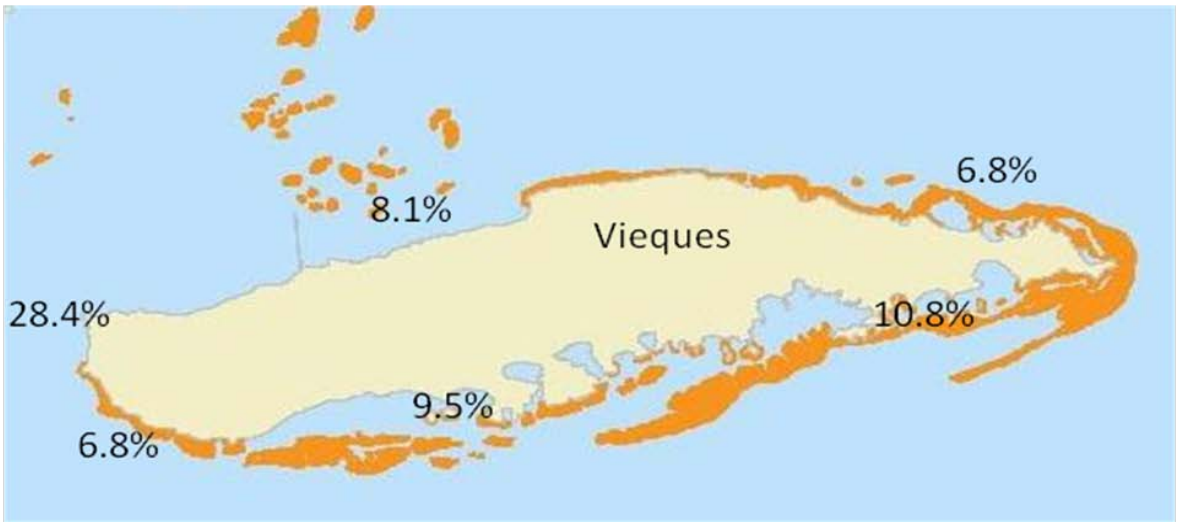


Figure 17: Recreational vessel use patterns via Fajardo in Vieques

Recommendations

The LCNR case study provided a good example on the use of structured surveys to characterize recreational user groups in an area, which in this case were the water-based operations and recreational vessel operators. While the case study did not include commercial fishers, which is the other, major user group in the reserve, this was done to focus solely on recreational (and not fishery) uses. However, as suggested in one of the following recommendations, a more complete characterization must include *all* LCNR stakeholders. Importantly, the approach demonstrated that primary data collection with stakeholders can provide meaningful information as it relates to carrying capacity and limits of acceptable change, and that stakeholders represent a diverse conglomeration of user types and experiences that can often have differing views on what and how much is acceptable. At the same time, however, stakeholder studies can also assist in improving knowledge, as the groups are a source of local ecological knowledge and trends, and they can be used to both provide baseline information and trend data on changes in resource conditions.

Water-based operators should be incorporated into a resource monitoring program that measures resource and user conditions and trends and which builds on the biophysical understanding of the LCNR

Because the water-based operators in the LCNR are licensed concessionaires, the operators should be recruited as partners in a long-term monitoring effort that evaluates changes in resource quality and user trends. Operators can complete an annual (or more frequent) survey that measures resource conditions and trends in the areas where the operators take their trips. Also as part of this effort, operators can administer or distribute self-administered visitor surveys to develop a visitor baseline. The establishment of such a baseline is paramount in determining how visitors perceive the LCNR in the future and whether (and the types of) changes affect visitor satisfaction. Moreover, depending on the types of activities in which the operators engage, surveys can be modified to establish baseline conditions for diving, snorkeling, beach visitation, and other uses. Of particular interest would be operators' and visitors' views on coral reef conditions, as measured by objective factors such as extent

of physical damage, bleaching, debris, etc., as well as qualitative factors such as reef health, overall abundance of fish, crowding conditions, etc.

Stakeholder use patterns and perceptions on present conditions should be determined in considering the need for additional management measures

User capacity or levels of acceptable change can be best evaluated by determining the number and types of uses that occur within sites. As shown in the case study, operators stated different capacities based on the activities in which their clients engaged (ex. diving versus snorkeling, nature walks versus beach visitation, etc.), as well as on the amount of time that they had been operating in the LCNR. While these differences may indeed be consequences of activity types or generational baselines, the results can nevertheless be used as guides in establishing maximum visitor loads. Examples of management mechanisms may be the rotation of sites where possible (ex. utilizing the water-based operator trip frequencies and patterns), mooring buoy placement, and visitor education (ex. to increase capacity by managing impact via education).

Registered vessel operators should be characterized to better understand vessel use patterns in the eastern region, including within the LCNR and LPNCR, to both determine operators' views on resource conditions and trends, views on crowding, and acceptability of management options

Registered vessel operators represent the largest stakeholder group in the region and most likely the LCNR (and according to the water-based operators, recreational vessel populations within the LCNR have exploded over the past decade or longer). Moreover, registered vessel operators and their passengers participate in a number of recreational, water-based activities. It is important that the stakeholder group be characterized, both in terms of the extent and areas of use and types and frequencies of activities in which boaters engage, to determine the group's overall impact (at present and projected, or future, levels). As shown in the case study, registered vessel operators can be easily characterized via existing infrastructure (ex. vessel registration offices), and a survey can be developed to target either whole regions and regional use patterns or discrete areas such as the LCNR.

Other stakeholders, uses, and private rights in the LCNR should be considered in developing capacity and limits of acceptable change measures

While recreation is most likely the most dominant use in the LCNR, commercial fishing does occur and is permitted within reserve boundaries. Other activities that may occur within the nearshore boundaries of the reserve include kayaking and personal watercraft use. Several commercial fishermen also still take out visitors (especially from the Las Croabas area in Fajardo) without a concessionaire permit. Finally, the Hotel El Conquistador owns and operates beachfront infrastructure on Palomino Island, where hotel ferries transport thousands of visitors each week. Without a determination of *all* uses within the reserve, including those that occur at the reserve boundaries, at the margin (in terms of their legality), and across legal boundaries, management options to address capacity and limits of acceptable change would be at best incomplete and may be in the long term be rendered ineffective.

Tres Palmas Marine Reserve (TPMR)

Under Law 17, the Puerto Rico legislature established the Tres Palmas Marine Reserve (TPMR) on January 8, 2004, culminating a three-year process led by community groups in the municipality of Rincon to protect the region's coastal zone (CIEL, 2008a). Concerned over the potential for development of coastal resorts and other housing, the community groups began a grass-roots campaign in the early 2000s, arguing that Rincon relies on a clean environment for its economic health (Pendleton, 2002) and that TPMR must be established to guard against sedimentation and related development-based activities and fishing and other marine-based impacts.

TPMR is a marine reserve with a designation law that allows a regulation to be established anytime in the future to prohibit consumptive activities. Its boundaries cover 3.8 km and extend from the mean high-water line to a depth contour of 60 feet (CIEL, 2008b). The reserve abuts (and even includes part of) Steps Beach, a popular beach with tourists and locals, and it hosts seasonal snorkeling (summer) and surfing (winter). Resources within the reserve include strands of elkhorn coral (*Acropora palmata*), a species considered threatened and thus protected under the US Endangered Species Act (ESA) (Federal Register, 2008), as well as several other species of corals and octocorals. Much of the reserve is hardbottom, with sandy channels. Other species of interest (i.e. endangered or threatened species) within or near the reserve are sea turtles, that are known to nest on sites in Steps Beach, and humpback whales, which swim in waters deeper than but adjacent to the reserve (CIEL, 2008b).

In terms of actual uses of the reserve, beach visitation in Steps Beach, snorkeling along the elkhorn thickets, organized snorkel trips and occasional dive trips, and winter surfing comprise a majority of the activities (CIEL, 2008b). The beach does not contain any facilities and has no concessionaires; moreover, visitors need to park their vehicles in a small unpaved parking area at the end of a narrow entrance. Also, there are several other beaches in the vicinity, including the Rincon Balneario which has a large parking lot, concessionaires, and public facilities. Thus, while TPMR does attract large crowds, use is partly limited by a lack of access and no facilities.

The TPMR case study consisted of a series of interviews, conducted with representatives of various stakeholder groups (i.e. key informants) involved in and knowledgeable about the TPMR establishment process. These interviews were conducted using guiding questions but served as open-ended discussions on issues concerning the objectives of the reserve, condition and trends of reserve resources, and changes in use patterns and intensities. The goal of the case study was to use a mostly qualitative approach to determine whether stakeholders believed that there was a need to establish limits of acceptable change for the reserve and, if so, then what activities the stakeholders agreed should be monitored; that is, which conditions and/or uses should be prioritized for measurement such that if threshold conditions were breached (or were trending towards a breach), management could be enacted to abate the effects/uses.

All the users interviewed agreed that the TPMR has provided net benefits to the area protected, but their views on the overall effectiveness of the reserve varied. The commercial fishers interviewed stated that the main pressure on the reserve was never fishing, as most fishers did not use the TPMR prior to its designation. While ornamental fish were harvested from within the reserve, the reserve's small size did not result in an insurmountable displacement. Since its designation, the fishers interviewed did not believe that fish populations had increased, with the exception of ornamental fish species; they also did

consider the reserve as being able to export fisheries to areas outside the reserve. Conversely, members of other groups felt that the reserve has had positive fishery impacts. The dive and snorkel operations interviewed believed that fish populations had increased in the TPMR but acknowledged that the increase had been otherwise dampened by other, land-based impacts.

The dominant land-based impacts that all user groups perceived as the main threats to the reserve were development and development-based sedimentation. Others also pointed to pollution as a problem within the TPMR, based mainly on the lack of infrastructure to accommodate levels of present and potentially higher future use. Due to the topography on the land abutting the reserve, several user group members felt that sedimentation resulting from development had already compromised the integrity of the reserve. One respondent argued that the reserve had been set back by twenty or more years due to all the sedimentation that had entered the reserve from development upland of Highway 403. A few others blamed the sedimentation for what they perceived was a decline in the reserve's elkhorn coral population.

Finally, in terms of reserve conditions, all stakeholders interviewed stated that DRNA is not doing an adequate job in protecting the reserve. Instead, they argued, the stakeholders themselves do all the caretaking, which involves cleaning the reserve and the adjoining beach, informing visitors to keep off coral in the reserve, and ensuring that vessel operators do not anchor on coral when recreating in the reserve. One user pointed out that DRNA had not installed mooring buoys, which are necessary to prevent anchoring in the TPMR. Overall, the user groups had a mostly negative view of DRNA with respect to its role in resource protection and enforcement. It should be noted that these situations may exist because DRNA has not yet named an on-site manager for the TPMR.

The main users in the TPMR identified in the case study were dive and snorkel operations and land-based visitors consisting of tourists and locals recreating on Steps Beach, snorkelers (and occasionally, divers) who enter the reserve from Steps Beach and, less frequently, from the northern and southern boundaries of the reserve, and surfers who use the reserve on a very limited basis (i.e. when conditions favor surfing in the winter months). The study identified only a single operation that makes daily trips to the TPMR; two other water operators were identified, one of which uses the area for training dives and on other occasions but does not enter the reserve on a regular basis, and the other that enters the reserve occasionally. The operation that makes daily trips takes out an average of 15 snorkelers per trip, or approximately 3,000 snorkelers per year. The operation enters either from the northern or southern boundaries of the reserve, and snorkelers are educated about and warned not to touch corals.

Apart from the single operation using the TPMR on an annual basis, at least one other operation rents snorkel gear to visitors who use the reserve. The operation estimates that it rents between 2,500 – 3,000 snorkel gear sets each year, of which most are used by renters in the TPMR; in fact, the operation provides information on the reserve to renters, describing how to access the reserve, the best snorkel routes, and warnings to avoid touching corals. While at least one other store also rents snorkel gear infrequently, it is unclear whether and to what extent the visitors use the reserve, which is located south of the store.

No reliable estimates for beach visitors were obtained from stakeholders interviewed for the study. One respondent estimated that 99% of TPMR use originates from land (ex. shore-based snorkelers), and that the three operators represent 1% of the remaining use that originates from sea. Another stated that, on average, there are between 30-45 visitors on Steps Beach each day, adding that the total may increase

to 60 or more visitors on special occasions (ex. when the surfing conditions are good, during holidays and special events, etc.). Also, several users stated that while they could not quantify the change, there had been a definite increase in the number of visitors in TPMR since its designation, which may require a need to control use in the near future.

Generally, visitors were unconcerned over capacity issues in TPMR. One respondent felt that because vessel-based use was largely limited by the lack of a local marina, the only restrictions required to address capacity should be those that control the number of land-based visitors. But even land-based tourism may be limited by other factors, as pointed out by several users, since parking spaces are sparse, there are no facilities on the beach, the small, overall size of the beach, and the availability of other excellent beach and snorkeling sites (these include Barrero Beach and Shacks Beach, among others). While some users did believe that certain conditions had deteriorated in the reserve, including increased turbidity and coral damage, they blamed factors other than visitation (i.e. sedimentation resulting from upland development) for the impacts. Finally, stakeholders did not perceive increased visitor loads as antithetical to the reserve objectives as long as tourism did not result in resource damage and pollution, both impacts which could be managed by education (ex. brochures and other literature, operator briefings, etc.) and improved beach maintenance (ex. enforcement of beach pollution, toilet facilities, trash receptacles, etc.).

Recommendations

Many of the recommendations proposed for the TPMR reflect the need for characterization studies whose results can be used to establish a baseline on biophysical and socioeconomic conditions. These results will prove useful in demonstrating the effectiveness of the reserve in achieving its objectives and facilitate the determination of capacity-based impacts, as these relate to the effects of increased visitation on TPMR resources, perceptions of visitors and other users on biophysical and socioeconomic conditions within the TPMR, and their willingness to support limits on visitor loads, snorkelers, surfers, and vessels, among others.

Visitor totals, including seasonal trends, in the TPMR should be estimated, as well as a visitor characterization study

There is a need to determine the overall visitation in the TPMR, leading to the establishment of a total use baseline against which future trends can be compared. Such an estimate must measure 'pulse' periods, such as when surfer visitation increases, and seasonal changes, comparing winter and summer rates. Accompanying visitor estimates, a survey-based study should be conducted with a sample of visitors over the period of one year to characterize the reserve's visitor population. The survey should include questions on visitor demographics, visitation reasons and frequency, views on resource conditions, and perceptions on crowding and the need for limits on visitors and/or activities.

There is a need for a coupled biophysical and socioeconomic monitoring program to evaluate the impacts of visitation on the reserve's resources and those of the resource conditions on visitor satisfaction (and hence support for the reserve)

Resource conditions should be monitored in the reserve to evaluate management effectiveness; however, the biophysical conditions must be monitored in conjunction with estimates of visitor loads and use frequencies to determine whether changes in visitor totals and activities affect resource conditions and, if so, then if these result in the need to address visitor capacity.

Capacity, if considered an important management objective, should be implemented by exploring existing limiting mechanisms

As shown in the case study, there already exist means by which visitor loads are limited within the TPMR. These include sparse infrastructure (parking and facilities), few access points, the small size of the beach, the lack of a marina that would otherwise lead to higher vessel traffic (as well as strong wave action in winter months), and the availability of high quality, substitute sites. If limits were to be established such that visitor loads would be controlled, then this can be best achieved by enhancing the so-called 'pull factors' (i.e. publicizing other sites to spread out use) and 'push factors' (i.e. minimizing the level of facilities at Steps Beach, reducing the amount of parking available, and not promoting the reserve, etc.).

There is a need to determine the overall impacts of upland development on the TPMR, as such off-site activities coupled with increased visitation may act synergistically in compromising the biophysical integrity of the reserve and thereby reducing management effectiveness

Respondents in the case study argued that upland activities that lead to increased turbidity and thus damaged the reserve's coral reefs and related resources. Unless such impacts are quantified such that their effects are well understood (and hopefully mitigated), the impacts may compromise the reserve's natural resources to a point where the visitation-related impacts (ex. snorkeling inadvertently touching or breaking coral) may synergistically lead to even greater resource degradation with the TPMR.

Enforcement may need to be upgraded if the TPMR achieves increased biomass production and export

The commercial fishers interviewed in the case study stated that the TPMR was never consistently used as a fishing ground, except for ornamental fish collection. Other respondents claimed that the reserve did contain commercially important species and that they had observed increased populations of these species since the TPMR designation. If the reserve does increase biomass production (as could be measured by a biophysical monitoring program), then greater enforcement would be required to ensure that it is not poached. This would include the need for buoys demarking the boundaries of the reserve and increased surveillance.

Conclusions

As the coastal and marine NR system in Puerto Rico strives to preserve important natural resources while allowing for vital traditional and economic activities, it is imperative that a framework which incorporates these conflicting goals be implemented to ensure the sustainability of the system's resources, on which the socioeconomic uses depend. The LAC approach, with its focus on maintaining resource conditions within a range of or below threshold standards using a process that emphasizes public participation and stakeholder collaboration, offers such a framework. However, the first step to implementing an LAC or related framework, or even establishing carrying capacity numbers, is to characterize the stakeholder population.

Depending on the area, its attributes, and its stakeholders and their uses, preferences, and expectations, characterizations may vary considerably. As shown in the case studies in this report, different methodologies can be applied to characterize stakeholders and identify key issues (Babbie, 1990). These may consist of quantitative methods, such as administering formal surveys with different user groups, estimating use impacts from stakeholder statistics and use patterns, and developing use maps to identify areas of conflict and overuse, among others. Qualitative methodologies may include key informant interviews, ethnographies for stakeholder groups, and observations. The methodologies adopted for a study, as shown in this report, depend in part on the use profiles (ex. use types, magnitudes, and frequencies) and logistical constraints (ex. timing, funding, availability of trained personnel, etc.).

Without an understanding of how stakeholders interact with the protected area's resources and with each other, their views on resource conditions and trends, and their attitudes towards management options, approaches may otherwise omit important stakeholder attributes or expectations in developing management strategies. The result is often a loss in stakeholder confidence and trust in management (as measured among stakeholders in the Florida Keys National Marine Sanctuary who believed that the designation process had been largely arbitrary (Suman et al., 1999)), and it may in fact result in lower compliance and, in drastic cases, the loss of legitimacy (Kelleher, 1999).

The recommendations provided for a recreational vessel operator research program and the individual case studies in this report are thus 'stand-alone' recommendations and do not apply to other sites, even those that may be superficially similar to the sites considered in the report. Instead, as a general recommendation, it is suggested that DRNA commence on a path towards estimating and managing visitor and other use impacts by first characterizing uses in its coastal and marine NR system. Once the interactions between resources and stakeholders have been characterized, there are several, tested methodologies that can be applied to assess visitor and other use impacts, such as the Visitor Experience and Resource Protection (VERP) approach (NPS, 1997), the Visitor Impact Management (VIM) system (Graefe et al., 1990), and others (Nilsen and Tayler, 1998), Without establishing stakeholder, and indeed natural resource, baselines, the application of an LAC or other capacity framework cannot succeed.

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APPENDICES

Appendix I: Recreational vessel operator survey instrument

ENCUESTA DE BARCOS REGISTRADOS EN PUERTO RICO

1. Cual es el código zip de su residencia principal? _____

2. Cual es su puerto principal de embarco o salida?_____

3. Cual de lo siguiente incluye su edad?

   [ ] Menos de 18 años [ ] 18-30 [ ] 31-40 [ ] 41-50 [ ] 51-60

   [ ] Mas de 60 años

4. Por cuantos años ha estado usando (o ha tenido) una lancha en Puerto Rico?

   [ ] Menos de 1 año [ ] 1- 5 [ ] 6-10 [ ] 11-15 [ ] 16-20

   [ ] Mas de 20 años

5. Cuantas veces al mes usa su embaración?

   a. Dias de semana por mes (entre 1-22 dias)

   [ ] 1-3 [ ] 4-7 [ ] 8-11 [ ] 12-14 [ ] 15-17 [ ] 18-22

   b. Dias de fin de semana por mes (entre 0-8 dias)_____

   [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8

6. Cuantas horas dura su viaje por embaración? _____horas

7. Cuantas personas usualmente van con usted en su embaración (incluyendo usted)?

   [ ] Yo solo [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] mas que 7

8. Cual es su destino mas frecuente?_____

9. En su opinión, en que condición están los áreas que usted visita cuando toma un viaje en embarcación:

   [ ] Muy apretados (no tengo espacio para mis actividades)
   [ ] Mas apretados que no (tengo poco espacio para mis actividades)
   [ ] Normal
   [ ] Mas amplios que no (tengo bastante espacio para mis actividades)
   [ ] Muy amplios (tengo todo el espacio necesario para mis actividades)

10. Usando la tabla abajo, por favor determina la frecuencia de los actividades en que usted participa cuando toma un viaje en su embaración.

Actividad	Siempre	La mayoría de los veces	La mitad de los veces	Ocasionalmente	Nunca
Pescar con cordel					
Pescar con harpon					
Bucear					
Snorkel					
Nadar					
Ski					
Pasear en bote					
Visitar playas					
Otro _____					

11. En los actividades en que usted participa cuando toma un viaje en su embaración, cuantos otros botes/lanchas ve usted a su alrededor durante un viaje típico?

[ ] 1-5 [ ] 6-10 [ ] 11-15 [ ] 16-20 [ ] 21-25 [ ] 26-30 [ ] mas que 30

12. Cual es la cantidad MAXIMA de otros usuarios (o botes) que usted tolera antes de ir a buscar un otro sitio para su actividades?

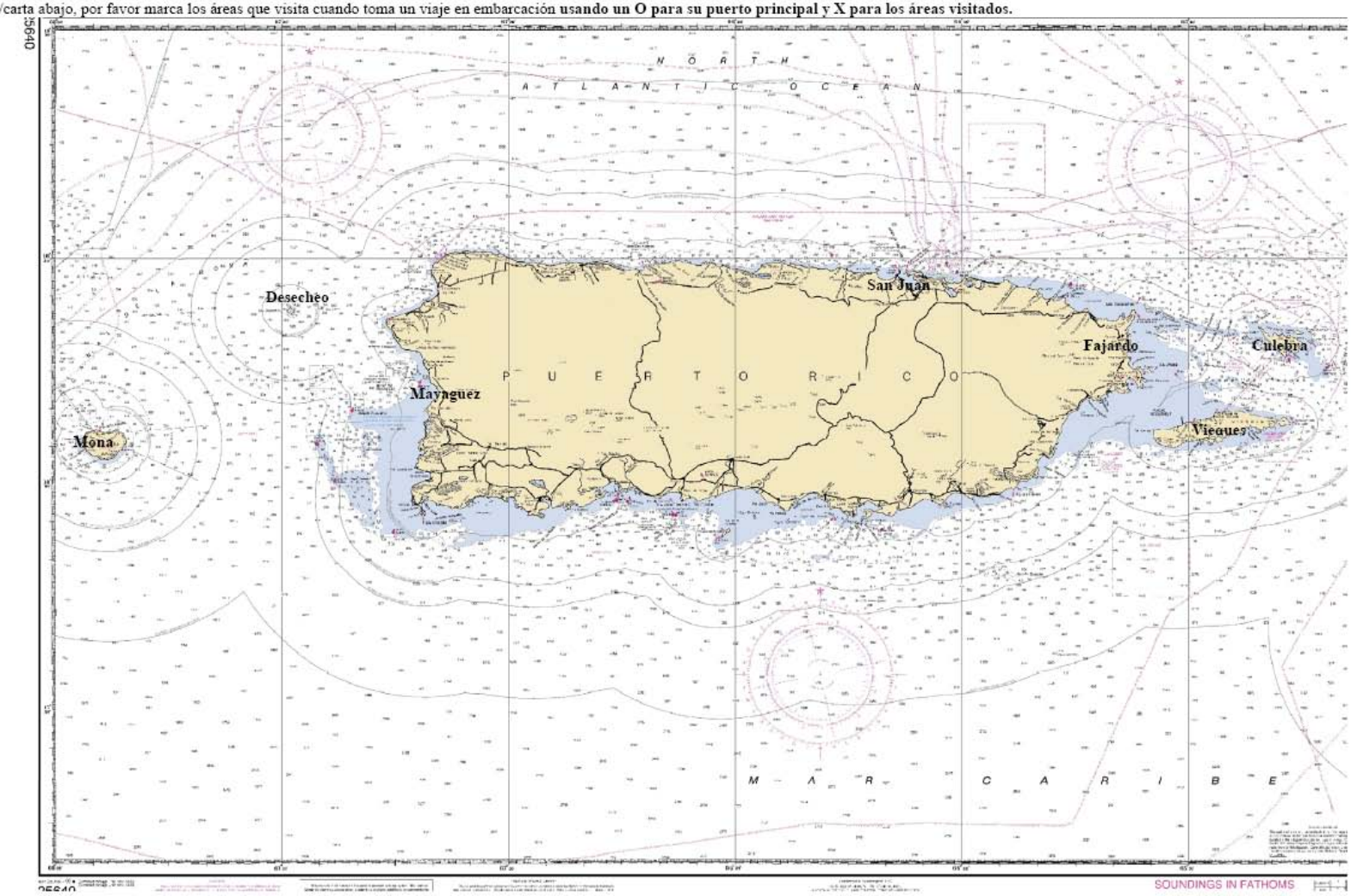
[ ] 1-5 [ ] 6-10 [ ] 11-15 [ ] 16-20 [ ] 21-25 [ ] 26-30 [ ] mas de 30

13. Cuáles serían las medidas favorecidas para controlar el número de embarcaciones en un lugar en particular? Por favor alinea su opinión de las siguientes formas de controlar uso y/o acceso.

Forma de controlar uso y/o acceso	1 – en favor	2	3 - neutral	4	5 – no en favor
Limites diarios de botes en el area					
Limites por permisos especiales (ex. licencias o entradas)					
Limites en boyas de anclaje					
Áreas de no acceso o anclaje					
Otro _____					

ENCUESTA DE BARCOS REGISTRADOS EN PUERTO RICO

14. Usando el mapa/carta abajo, por favor marca los áreas que visita cuando toma un viaje en embarcación **usando un O para su puerto principal y X para los áreas visitados.**



Appendix II: LCNR water-based operator survey

Nombre_____

Dirección_____

Telefono_____

1. ¿ Cuántos años tiene usted? _____

2. ¿ Cuántas personas du su familia dependen de usted?
   Usted solo 2 3 4 5 6 7 Mas que 7

3. ¿ Cuál es su nivel educativo?
   Menos del colegio Colegio Universidad Estudios graduados

4. ¿ Pertence usted a algunos grupos o organizaciónes de buzo, locales?
   SI NO
   -- Si pertence, entonces cuáles?_____

5. ¿ Cuál puerto/muelle considera usted como su puerto/muelle principal?_____

Si usted tiene los puertos estacionales, por favor los listan por temporada:
_____

6. ¿ Por cuántos años ha sido un operador?_____
   - ¿ Por cuántos años ha sido un operador en la Cordillera RNA?_____

7. Proporcione por favor un estimación de remplazo de los siguientes articulos que usted uso en perquerías comerciales.
   a. ____barco(s) y equipo electrónico: $_____
   b. Equipo de buceo: $_____
   c. Otro equipo_____ $_____
   d. Numero de empleados F/T_____: P/T____

8. Proporcione por favor su MEJOR estimación para los gastos siguientes durante un año tipico.

   a. Gastos de marina: $_____
   b. Honorarios/gastos de procesador: $_____
   c. Pagos de interes para su barco(s): $_____
   d. Mantenimiento y reparación de su barco(s): $_____
   e. Mantenimiento y reparación de su equipo: $_____
   f. Licencias: $_____
   g. Seguro del barco(s): $_____

9. Caracteristicas del embarcación
   a. Capacidad de pasajeros total_____
   b. Capacidad de buceadores_____; capacidad de snorkelers_____

10. Actividades principales (indica todos lo que aplican)
    Buzo Snorkeling Pasear/playas Transportación Otros_____

11. Numero de viajes en un año tipico
    a. Numero de viajes en total_____
    b. Numero de visitantes por viaje_____
       i. Numero de buceadores_____
       ii. Numero de snorkelers_____

12. . Toma viajes consumativos (e.j. buzo con arpón, pescar langosta)? SI NO
    - si SI, entonces que porcentaje de su viajes total son consumativos?_____%

13. Desde cuando comenzo a usar la Cordillera RNA, cual de los siguente cambios ha observado?
    a. Numero de barcos comerciales: +/-_____%
    b. Numero de lanchas privadas: +/-_____%
    c. Numero de visitantes: +/-_____%
    d. Numero de buceadores: +/-_____%
    e. Numero de gente en las playas: +/-_____%

14. Trata usted de cambiar su viaje si vea que hay demasiado usuarios en un lugar?
    a. Siempre
    b. De vez en cuando
    c. Nunca
    - Para usted, que cantidad de usuarios significan demasiado? _____numer
    - Para usted, que cantidad de usuarios significa aceptable?_____numero

15. En terminos de capacidad, cuantos usuarios MAXIMO al misma vez deben usar los siguente recursos en la Cordillera RNA para asegurar su sostenibilidad:
    a. Sitios de buzo/snorkel _____
    b. Playas _____

16. Por favor, ranga el nivel del conflicto que tiene con los siguente otros grupos.

a. Otros concesionarios	1	2	3	4	
b. Pescadores deportivos	1	2	3	4	
c. Buzos deportivos	1	2	3	4	
d. Botes deportivos	1	2	3	4	

17. Por favor, alinea el condicion de los siguente recursos marinos en la reserva natural de la Cordillera, en terminos de los cambios que han pasado desde cuando comenzo a pescar.

a. Arrecifes de coral (blanquimiento, enfermedades, corales rotos)	1	2	3	4	5	n/a
b. Pastos del mar	1	2	3	4	5	n/a
c. Manglares	1	2	3	4	5	n/a
d. Calidad de agua	1	2	3	4	5	n/a
e. Limpieza	1	2	3	4	5	n/a
f. Abundancia de peces	1	2	3	4	5	n/a
g. Nivel del conflicto	1	2	3	4	5	n/a
h. Espacio para navegación	1	2	3	4	5	n/a
i. Daño por anclaje	1	2	3	4	5	n/a
j. Daño por barcos	1	2	3	4	5	n/a