Ecology and Management of Bonefish (*Albula* spp) in the Bahamian Archipelago


Cape Eleuthera Institute, Flats Ecology and Conservation Program, Eleuthera, Bahamas
*Carleton University, Institute of Environmental Science, Ottawa, Canada
**Department of Pathobiology, University of Illinois, Urbana, IL USA
***Illinois Natural History Survey, Center for Aquatic Ecology and Conservation, Champaign, IL USA

CONTENTS

Abstract
Introduction
History of the Bonefish Fishery
  Subsistence Fishery
  Recreational Fishery
Ecology of Bonefish in The Bahamian Archipelago
  General Applicability
  Distribution and Abundance
  Habitat Use and Movements
  Feeding Ecology
  Population Dynamics
Current Conservation and Management Strategies for Bonefish
Research and Conservation Needs
Acknowledgements
Literature Cited

ABSTRACT - Bonefish (*Albula* spp) are common within the Bahamian Archipelago and play an important role in supporting the regional economy. Despite their importance, little formal scientific information is available on the ecology or population dynamics of bonefish stocks relevant to their conservation and management in the Bahamian Archipelago. Although the popularity of bonefish as a recreational sportfish has generated ample anecdotes about the ecology of bonefish in The Bahamas and the Turks and Caicos Islands, lack of a holistic approach to understanding spatial and temporal variation in bonefish populations currently prevents the development of sound management plans to conserve the resource. Of the handful
of formal studies conducted on bonefish in the Bahamian Archipelago, most have focused on movements, habitat use, and feeding ecology. More recently, attention has also been paid to determining whether or not catch-and-release angling, a conservation measure voluntarily practiced by recreational anglers, is effective in helping to maintain local populations. Given the importance of tourism to the economies of The Bahamas and the Turks and Caicos Islands, and that many tourists visiting these islands fish recreationally for bonefish, a better understanding of the basic ecology of bonefish, including the potential impacts of fishing and anthropogenic disturbances on populations, is essential for the formulation of viable management strategies.

**INTRODUCTION**

Bonefish (*Albula* spp) are an important group of fishes inhabiting shallow, nearshore marine environments worldwide. Historically, bonefish have played a strong role in supporting local and regional economies of the Bahamian Archipelago (i.e., The Bahamas and the Turks and Caicos Islands) (Alexander 1961; BEST 2002, 2005), an extensive expanse of shallow bank environments that comprise nearly 90% of the 300,000 km² archipelago (Sealey 1994, Buchan 2000). The ample nearshore habitats of the Bahamian archipelago make bonefish readily accessible to local residents and visitors of this unique island chain (Kaufmann 2000).

Despite their regional economic and ecological importance, relatively little scientific information exists to assist assessment or conservation management of bonefish in the Bahamian Archipelago. The purpose of this paper is to review the history of the Bahamian bonefish fishery, and to highlight ecological and fishery research that has been conducted on bonefish in the Bahamian Archipelago, either as a target species or incidentally as part of other studies. This synthesis and analysis will help to identify information gaps in the Bahamian Archipelago that need to be filled before bonefish stocks can effectively be managed and conserved.
History of the Bonefish Fishery

**Subsistence fishery**

For generations, bonefish have been the focus of subsistence and artisanal fisheries in The Bahamas and the Turks and Caicos Islands (Olsen 1986, BEST 2002, BEST 2005). Catches of bonefish tend to be sold to individuals or small restaurants in rural communities where bonefish were a favored species of finfish for consumption (Olsen 1986). Although subsistence and small-scale commercial harvesting was traditionally conducted in relatively shallow waters using hand-lines or by ‘hauling’ seine nets (Olsen 1986). Recently monofilament gill nets have been employed for the harvest of bonefish in some areas. Unfortunately, these gears are non-selective, resulting not only in excessive harvests of bonefish, but also in substantial bycatch of other important species (e.g., turtles, barracudas, dolphins, sharks) (Clark and Danylchuk 2003).

Use of bonefish as a subsistence food item has declined in recent decades (Rudd 2003). Attrition of old-time ‘haulers’ and the increased availability of commercially produced food items to local communities have contributed to the decreased reliance on bonefish as a staple food. In addition, the social stigma of bonefish as a ‘poor man’s’ food to some extent has reduced its popularity among islanders (Rudd 2003).

**Recreational fishery**

As subsistence and small-scale commercial fisheries for bonefish in the Bahamian Archipelago have subsided, bonefish have gained importance as a target species for specialized recreational anglers. Angling for bonefish has become extremely popular because their wary nature and powerful swimming abilities when hooked makes them a challenge to catch using lightweight fly fishing and conventional hook-and-line gears (Kaufmann 2000, Davidson 2004, Fernandez 2004). In addition, the remoteness and tranquil beauty of subtropical and tropical
locales and serene qualities of the “flats” environment has turned bonefishing into a highly sought-after ‘holistic’ angling experience. The clear, unpolluted waters of the Bahamian Archipelago with abundant bonefish and proximity to the United States are all draws for well-healed recreational anglers (BEST 2002).

Interest in sportfishing has influenced the development of tourism-based industries specifically focused on recreational angling for bonefish. From fishing tackle and guiding fees to travel and accommodations, the amount of direct and indirect revenues from the bonefishing industry can be high (Humston 2001). For example, in the Florida Keys regional economic contributions of the recreational industry centered on bonefishing generates a billion dollars in revenue per annum (Humston 2001; Ault et al., this volume). In developing countries, such as The Bahamas and Turks and Caicos Islands, local communities can be solely reliant on revenues generated by recreational bonefishing, especially when there is a paucity of alternative sources of revenue.

In The Bahamas, tourism represents more than 50% of the annual gross domestic product, making tourism the largest single contributor to the country’s economy (Buchan 2000, BEST 2002). Recreational angling is a popular activity for tourists visiting The Bahamas and the Turks and Caicos Islands, many of whom dedicate their entire trip to fishing for bonefish. Of the 1.5 million tourists in 2004 who filled out immigration departure forms in The Bahamas, 5000 (0.3%) of these individuals stated that the purpose of their trip was for ‘bone/fly fishing’ (Government of The Bahamas, unpublished data, 2004). Most of these tourists who visited primarily for angling responded that their ‘bone/fly fishing’ trip targeted the “family islands” such as Abaco, Andros, and Eleuthera (Figure 1). Almost all respondents (92%) were from the United States, and most of these individuals were from the southern (41.1%) or northeastern
areas of the country (28.8%) (Government of The Bahamas, unpublished data, 2004).

Ecology of Bonefish in the Bahamian Archipelago

General Applicability

Research conducted on the ecology of bonefish in the waters of the Bahamian Archipelago has been relatively limited. Fewer than ten peer-reviewed scientific publications have been produced that specifically focus on bonefish (e.g., Colton and Alevizon 1983a,b, Clark and Danylchuk 2003, Cooke and Philipp 2004, Danylchuk et al. Accepted) or that sampled bonefish as part of broader research questions (e.g., Layman and Silliman 2002, Laymen et al. 2004, Nero and Sealey 2005). Although research conducted on bonefish in other parts of the world can provide some insights into the ecology and management of bonefish inhabiting the Bahamian Archipelago, studies by Pfeiler et al. (2000) and Colborn et al. (2001) have revealed the potential existence multiple species of bonefish across several spatial scales. This brings into question the legitimacy of extrapolating results across geographic regions because different species may have vastly different life histories and behavioral patterns. Most accounts in the scientific literature refer to bonefish inhabiting the Bahamian Archipelago as *Albula vulpes*, however rarely has the species identity of these populations been confirmed through genetic and morphometric analyses. An exception is a study by Bowen et al. (2003) which identified both *A. vulpes* and a second species (nova or species b) in a sample of bonefish collected from Bimini, although their overall sample size was relatively small. Regardless, comparative studies of genetics and morphometrics for bonefish may help to clarify whether distinct stocks occur across the Bahamian Archipelago and help lay the framework for ecological studies and management plans.

Understanding the ecology of bonefish in the Bahamian Archipelago could be complicated by the sheer size and unique oceanographic features characteristic of the region
Ecology & Management of Bahamian Bonefish

The Bahamian Archipelago is made up of a series of banks distributed on a southeast to northwest axis to the north of Cuba and Hispaniola that are separated by deep expansive oceanic troughs (Sealey 1994, Buchan 2000). The strong northward flowing oceanic currents of the Gulf Stream to the west and the Antilles Current to the east interact with these banks and troughs to generate complex patterns of water circulation that can influence the recruitment, distribution, abundance, and genetic differentiation of marine organisms on a regional scale (Gunn and Watt 1982, Colin 1995, Almada et al. 2001, Floeter et al. 2001). Similarly, variation in bathymetry and tidal currents generated by the close proximity of land masses and the influence of wind on water movement across the shallow banks (Smith 2004a,b) could influence the ecology of bonefish populations. As such, extrapolating the results of other studies to bonefish in the Bahamian Archipelago (or vice versa) should be done with caution until the extent of the variation in systematics and ecology of bonefish populations in the region are more thoroughly examined.

**Distribution and abundance**

Anecdotal observations by subsistence fishers, recreational anglers, and guides indicate that bonefish are widely distributed throughout the Bahamian Archipelago. Popular media articles and books on bonefish often provide extensive detail as to the regional and local distribution and relative abundance of bonefish the Bahamian Archipelago (e.g. Kaufmann 2000). For instance, Kaufmann (2000) highlights the Abacos, Andros Island, Berry Islands, Bimini, Crooked and Acklins Islands, Eleuthera including Spanish Wells and Harbour Island, the Exumas, Grand Bahama Island, Great Inagua, Long Island, and the Turks and Caicos as prime destinations for recreational angling for bonefish. Undoubtedly bonefish reside in the waters adjacent to other islands in the Bahamian Archipelago, however, their presence, distribution, and relative
abundance is not generally known.

Although it is recognized that bonefish are distributed throughout the Bahamian Archipelago, no formal studies have been conducted to determine their distribution and relative abundance across a range of spatial and temporal scales. Recreational anglers and guides often comment on relative differences in the abundance and size structure of bonefish inhabiting different islands in the Bahamian Archipelago and during different seasons (Kauffmann 2000), however, there has been no formal study or population census quantitatively assessing the abundance of bonefish in the region or whether spatial and temporal patterns in abundance do in deed exist. Spatial and temporal variation in the abundance of bonefish both within and among distinct regions of the Bahamian Archipelago could be related to intrinsic (e.g. reproductive ecology, species distribution) and/or extrinsic factors (e.g. oceanography, predation), and identifying the relative influence of such factors on bonefish abundance is crucial to developing reliable conservation management plans.

**Habitat use and movements**

Bonefish in the Bahamian Archipelago generally inhabit shallow, nearshore waters (Kauffmann 2000). Studies on the localized movements of bonefish in The Bahamas have suggested that bonefish utilize the range of nearshore habitats, including seagrass beds, mangrove creeks, and even coral reefs (Colton and Alevizon 1983a, Colton and Alevizon 1983b, Cooke and Philipp 2004, Danylchuk et al. unpublished data). Articles in popular angling publications and ancillary information garnished from recreational anglers and guides indicate that bonefish in the Bahamian Archipelago are also often observed and caught from other habitat types within the nearshore flats environment (Kauffmann 2000), including sandy flats devoid of benthic vegetation (Layman and Silliman 2002, Laymen et al. 2004, Nero and Sealey 2005).
Nearshore movements of bonefish within the Bahamian Archipelago have received some attention. Colton and Alevizon (1983a) used ultrasonic telemetry to examine the activity and daily movements of bonefish in waters near Deep Water Cay off Grand Bahamas Island. Of 13 fish surgically implanted with transmitters, only three were relocated more than 24 hr post-release. The inability to detect ten of the transmitter-implanted bonefish could have been attributed to predation following release or their movement out of reception range. The three remaining bonefish were tracked for between 5 and 100 d post-release, and their movements tended to be synchronous with the ebbing and flooding tides (moving into deeper water with ebbing tides and moving into shallow flats on flooding tides). On Andros Island, Nero and Sealey (2005) attributed variability in fish abundance among sites, including bonefish, to tides as well as to season, however their data were not sufficient to determine if specific coastal or benthic factors were driving observed differences. Bohlke and Chapman (1993) also reported that bonefish move into deeper water at slack low tides, with large schools being observed at depths of over 15 m below the edge of the drop-off in the Tongue of the Ocean near Green Cay. Such movements are similar to the reoccurring localized pattern observed by Humston et al. (2005) for bonefish studied with acoustic telemetry in the Florida Keys, and by Colton and Alevison (1983a) for bonefish at Deep Water Cay in The Bahamas. Both studies inferred that the bonefish movement into deeper channels was attributed to avoidance of high water temperatures associated with shallow flats. In the case of Deep Water Cay, Colton and Alevison (1983a) noted that the proportion of large fish (> 555 mm FL) was inversely correlated with inshore water temperatures, and that these observations were supported by anecdotal information provided by guides, anglers, and lodge owners.

Bonefish movement and migration patterns in the Bahamian Archipelago may also reflect
the distribution and abundance of predators (Cooke and Philipp 2004, Humston et al. 2005, Danylchuk et al. in press). Although Humston et al. (2005) suggested that Florida Keys bonefish may avoid deep channels frequented by sharks, several recent studies in The Bahamas demonstrated that even bonefish in shallow waters (i.e., <0.5 m depth) are susceptible to predation, particularly following catch-and-release angling (Cooke and Philipp 2004, Danylchuk et al., unpublished data). Predation may have also affected the observations made by Colton and Alevizon (1983a) about the long-term movement patterns of bonefish at Deep Water Cay, since their lack of detection of transmitter-implanted fish or the recapture of externally tagged fish may have been caused by bonefish migrating out of the study area, or by predation by sharks or barracudas following release.

Movements of bonefish in the Bahamian Archipelago may be related to body size, reproductive maturity, spawning migrations, or ontogenetic shifts in feeding habits (Colton and Alevizon 1983a, Bohlke and Chaplin 1993). According to anecdotal accounts by Bahamian fishermen, large bonefish appear to return to tidal creeks in the fall where they aggregate in large numbers prior to spawning (Colton and Alevizon 1983a). It is also commonly observed that schools of bonefish are generally comprised of small to medium-sized fish, while larger individuals tend to be more solitary, at least outside the spawning season (Bohlke and Chaplin 1993). In the Turks and Caicos Islands, Clark and Danylchuk (2003) collected a total of 120 bonefish ranging in size from 28 to 72 cm TL as part of a tag-and-release study to determine movements on the Caicos Bank. During the course of the study only one tagged bonefish was recaptured, with the fish being caught by a local hauler using a seine net (Clark and Danylchuk 2003). They noted that the mean size of bonefish increased from west to east across Caicos Bank, potentially indicating ontogenetic shifts in habitat use. Local fishermen from South
Caicos have also reported schools of large bonefish over offshore patch and coral reefs close to the wall of the Columbus Passage during winter months, and they believe that these aggregations might be related to spawning activity.

**Feeding Ecology**

Several diet studies that examined stomach contents have been conducted on bonefish in the western Atlantic (e.g., Warmke and Erdman 1963, Crabtree et al. 1998), with two of these in The Bahamas (Colton and Alevison 1983b, Layman and Silliman 2002). In all studies, bonefish were found to feed predominately on benthic invertebrates, but occasionally on small fishes. In Deep Water Cay, Colton and Alevizon (1983b) examined the stomach contents of 393 bonefish that ranged from 25 to 69 cm FL. Only 7% of stomachs were empty. Over 88% of the diet was comprised of invertebrates, with bivalves and crabs making up the majority of the biomass (dry weight) consumed (Colton and Alevizon 1983b). Other prey items included small benthic fishes, such as gobies. Colton and Alevizon (1983b) also indicated that the dietary composition of bonefish differed among sand and seagrass habitats, likely related to the availability of prey items. Layman and Silliman (2002) examined the diet of considerably smaller bonefish (mean size of 13.8 ± 0.4 cm) in creek systems on Andros Island and found that 90% had eaten crustaceans, with 40% being decapod crabs. The majority of the diet by volume was comprised of crustaceans (48%), mollusks (17%), and insects (18%) (Layman and Silliman 2002). Although their sample size was relatively small (n=10), Layman and Silliman (2002) did find that these small bonefish were most abundant over sand flats.

**Population Dynamics**

No formal studies on population dynamics of bonefish (e.g., age and growth, reproduction, survivorship) have been conducted in the Bahamian Archipelago. Only incidental
accounts of body size for bonefish in the Bahamian Archipelago have been reported in the scientific literature (Table 1). Those collected by scientific studies in general have tended to be smaller than those caught by anglers (Kaufmann 2000). For instance, bonefish exceeding 5 kg have been reported by guides and anglers across the Bahamian Archipelago, but not in primary scientific research. Nevertheless, if age and growth patterns can be generalized across regions in the western Atlantic, bonefish in the 10-12 lb range inhabiting the Bahamian Archipelago could easily be over 12 yrs old (Bruger 1974).

All information on the seasonal timing of bonefish reproduction in the Bahamian Archipelago is based on anecdotal observations made by local fishers, recreational anglers, and fishing guides. Anglers often comment on the release of milt or eggs when fish are handled, especially between January and May. Anecdotal observations made in the Bahamian Archipelago suggest that bonefish aggregate and spawn in the fall, winter, and early spring (Nov-Apr). Mojica et al. (1995) studied larval recruitment patterns of *Albula* spp near Lee Stocking Island and found leptocephali during fall and early winter, in agreement with anecdotal observations and with maturation patterns for bonefish in the Florida Keys (Crabtree et al. 1997). However, Mojica et al. (1995) also noted a large pulse of recruitment during a single 72 d sampling period in the summer months, indicating that spawning may occur year-round in The Bahamas. Otolith analysis of larval duration for specimens collected near Lee Stocking Island ranged from 41 to 71 days. Almost all leptocephali were collected at night in the upper 1 m of the water column, and inshore movement was strongly associated with flooding tides and the new moon (Mojica et al. 1995).

**Bonefish Conservation and Management Strategies**
Despite their ecological and economic importance, fishery regulations for bonefish across the Bahamian Archipelago are limited. In The Bahamas, the capture of bonefish using nets and commercial trade bonefish are prohibited (Bahamas Department of Fisheries 1986). In the Turks and Caicos Islands, there are no specific regulations for bonefish (Turks and Caicos Government 1998a). At the same time, fishing guides in the Turks and Caicos Islands state that monofilament gill nets are being deployed across tidal creeks, resulting in the mortality of large numbers of juvenile and adult bonefish, as well as the bycatch of other important species such as marine turtles (Clark and Danylchuk 2003).

In an effort to conserve fish stocks and their habitats, both countries are using marine protected areas in conjunction with existing fisheries regulations to build sustainable fisheries and protect marine biodiversity (Turks and Caicos Government 1998b). Although a marine reserve was established in the Turks and Caicos Islands in 1992 with bonefish conservation specifically in mind, no formal scientific information was used in its design and implementation. Only recently has there been any effort to assess the efficacy of this particular marine reserve, or whether marine protected areas in general are useful for conserving bonefish stocks (Clark and Danylchuk 2003, Cooke et al. 2006).

One potential way in which bonefish in the Bahamian Archipelago are partially protected is through voluntary catch-and-release efforts (Cooke et al. 2006). Catch-and-release is commonly practiced by recreational anglers with a strong conservation ethic who travel to The Bahamas and the Turks and Caicos Islands. Catch-and-release angling can be an effective way to help maintain bonefish stocks only if the post-release mortality is minimized (Cooke and Suski 2005). When a fish is hooked by an angler, many factors affect the outcome of the event for the fish (Cooke et al. 2002; Cooke and Philipp, this volume). At best, the fish will survive
the event. At worst, the fish will not survive. Although anglers strive for the former outcome, an intermediate outcome in which the fish suffers transient physiological and behavioral impacts is probably more likely (Cooke and Philipp 2004, Cooke and Suski 2005, Bartholomew and Bohnsack 2005), can increase the susceptibility of released fish to predation (Cooke and Philipp 2005) and may ultimately lead to population-level effects.

Recently Bartholomew and Bohnsack (2005) highlighted a number of factors related to recreational angling that influenced the mortality of released fish. They concluded that catch-and-release angling was not compatible with the conservation objectives of no-take marine protected areas. In a response, Cooke et al. (2006) indicated that the effects of the factors identified by Bartholomew and Bohnsack (2005), such as hooking in vital organs and angling duration and handling, could be reduced to the point where the fishing mortality rate approached zero increasing the likelihood of integrating catch-and-release angling with no-take reserves. Determining whether catch-and-release is a useful tool for bonefish conservation requires more attention, especially as there is an increase in the demands of recreational anglers seeking bonefish along with the associated tourist operations supporting this activity (Crabtree et al. 1998, Cooke and Philipp 2004, Bartholomew and Bohnsack 2005, Cooke et al. 2006). Some studies have examined the short-term (24-48 h) mortality of bonefish following catch-and-release angling. In The Bahamas, these studies have found that predation of bonefish by lemon sharks (*Negaprion brevirostris*) and barracuda (*Sphyraena barracuda*) can range from 0 to 39%, with predation rates being correlated with the relative abundance of predators (Cooke and Philipp 2004, Danylchuk et al., in press) and/or the handling practices of anglers (Sascha Danylchuk, unpublished data). Post-release predation rates on bonefish could be regulated by the actions of anglers, potentially reducing the impacts of catch-and-release angling and making...
this activity more compatible with the conservation goals of no-take reserves (Cooke et al. 2006).

**Research and Conservation Needs**

A systematic, integrative, and cooperative approach is clearly needed to better understand and manage bonefish populations in the Bahamian Archipelago. Developing effective ecosystem management plans depends greatly on a comprehensive understanding of the systematics, biology, ecology, and population dynamics of bonefish throughout the region. Identifying if unique bonefish stocks occur (by compatible genetic and morphometric methods) in the Bahamian Archipelago is of primary importance, since stock mixing could significantly complicate management of the species. To determine whether traits in bonefish populations vary significantly across the large spatial scale of the Bahamian Archipelago, basic information on the genetic identity, age, growth, and reproductive potential (e.g. size and age at maturity, fecundity) needs to be collected at multiple locations across the region as part of a coordinated Bahamian Archipelago-wide sampling (monitoring) and assessment effort. Such an Archipelago-wide program would help encompass potential variation in bonefish populations associated with different properties of individual shallow water banks (e.g., degree of physical isolation, interactions with major oceanographic currents, latitude, etc.). Such sampling should occur at regular intervals throughout the year to determine whether the population structure of bonefish varies temporally, potentially related to spawning migrations, recruitment, and/or climatic patterns. Sampling the age, growth, and reproduction of bonefish populations at multiple locations throughout the year will allow for the examination of age- and size-specific trends in the allocation of energy to gonad development that, in turn, would help quantify the spatial and temporal patterns in the phenology of reproduction for bonefish across the Bahamian Archipelago. At selected focal research sites, the input of bonefish leptocephali could be
monitored using channel nets or light traps as a way to cross-validate the seasonal timing of reproduction inferred through the direct examination of gonad development. In addition, movement studies of bonefish using remote acoustic telemetry could be conducted in concert with the examination of gonad development and larval input to help determine where spawning activity actually occurs.

Given that the nearshore environment of the Bahamian Archipelago is relatively diverse at both the local and regional scales and that the region is prone to environmental extremes (e.g., high summer water temperatures, freshwater input, hurricanes), understanding how natural variation and natural disturbance regimes shape bonefish populations will allow for a more thorough evaluation of how anthropogenic disturbances may affect bonefish stocks (Cooke and Philipp 2004, Sealey 2004). Such comparisons could be facilitated though before-after-control-impact studies (Underwood 1994), empirical studies on bonefish populations subjected to a range of natural and anthropogenic disturbances, and experimental or manipulative studies that target particular disturbances. For instance, the tourist industry is steadily increasing throughout the Bahamian Archipelago, often resulting in anthropogenic disturbances such as dredging and coastal eutrophication (Rudd 2003, Sealey 2004). The potential effects of such disturbances on bonefish populations could be examined by monitoring bonefish populations before and after dredging or shoreline development in a particular area has occurred, specifically to test if modifying or eliminating foraging habitat has cascading impacts on bonefish distribution, life history traits, and ultimately abundance (Syms and Jones 2000, Gust et al. 2001, Hixon et al. 2001, Sadovy 2005). Similarly, comparative and manipulative studies may help differentiate the effects of recreational activities or if angling-related activities such as wading have detrimental effects on the integrity of nearshore habitats (Cooke and Suski 2005).
The interdependence of coastal environments of the small islands and the dependence of local communities on bonefish for income in the Bahamian Archipelago calls for a holistic and comprehensive management strategy to conserve and protect bonefish stocks. Although marine protected areas are often advocated and used throughout the Bahamian Archipelago as a low-cost tool for protecting habitats and species (BEST 2005, Dahlgren 2002, Danylchuk 2003, Lubechenco et al. 2003), they will only be effective if they balance the needs of society with the needs of the local marine resources (Murray et al. 1999, Hanna 2001, Roberts et al. 2001, Sealey 2003). With this in mind, determining whether or not catch-and-release angling is compatible with the conservation goals of marine protected areas is important (Bartholomew and Bohnsack 2005, Cooke et al. 2006). If recreational angling for bonefish is deemed compatible with marine protected areas, then the development of locally-based tourism focused on this activity could be promoted as part of a larger integrative management plan without disrupting the overall level of protection offered to the ecosystem (Cooke et al. 2006).

An effective Archipelago-wide sampling and management program for bonefish will depend greatly on collaborative partnerships between scientific institutions, pertinent local and regional governments, conservation organizations, and stakeholders. Integrating cooperative research with education and outreach programs throughout the Bahamian Archipelago will also instill the importance for marine conservation, including the protection of bonefish stocks. Only through such partnerships and education programs will realistic conservation management plans be developed that adequately encompass the needs of bonefish stocks as well as the sustainable development of local communities in the Bahamian Archipelago.
Acknowledgements

We gratefully acknowledge Chris Maxey and the Cape Eleuthera Foundation for financial and logistical support during the preparation of this chapter. Thank you to Earlston McPhee and Garry Young from The Bahamas Ministry of Tourism for providing statistics on bonefishing-based tourism in The Bahamas. Thanks to J. Ault and two anonymous reviews for their comments and suggestions on an earlier version of this chapter. We would also like to thank the many anglers, guides, and local fisherman who have provided invaluable anecdotes on bonefish, including S. Gardiner (Silver Creek Adventures), B. Jayne and G. Lockhart (Beyond the Blue Charters), B. Gardiner (Bonefish Unlimited), A. Dean (Silver Deep), F. Lockhart, T. Morris, S. Jennings, C. Leathen, R. Reckley, H. Rolle, A. McKinney, and D. Rankin. A special thanks also goes out to T. Davidson and R. Fisher (Bonefish and Tarpon Unlimited) for their guidance and support.

LITERATURE CITED


Service, Sport Fish Restoration Project F-59, Florida Marine Research Institute, St. Petersburg, FL, 252, 1998.


Nero, V.L. and Sullivan-Sealey K., Characterization of tropical near-shore fish communities by coastal habitat status on spatially complex island systems, *Environ. Biol. Fishes*, 73, 437,
2005.


Rudd, M.A., Fisheries landings and trade of the Turks and Caicos Islands, *University of British Columbia Fisheries Center Research Reports*, 11, 149, 2003.


Syms, C. and Jones G.P., Disturbance, habitat structure and the dynamics of a coral-reef fish


Table 1. Body size of bonefish reported in studies conducted for populations across the Bahamian Archipelago.

<table>
<thead>
<tr>
<th>Location</th>
<th>Length</th>
<th>N</th>
<th>Capture method</th>
<th>Purpose of study</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andros Is.</td>
<td>13.8 ± 0.4 mm SD</td>
<td>10</td>
<td>Cast net</td>
<td>Diet</td>
<td>Layman and Silliman (2002)</td>
</tr>
<tr>
<td>Deep Water Cay</td>
<td>50.5-61.0 cm FL</td>
<td>13</td>
<td>Angling (3), gill net (10)</td>
<td>Movement</td>
<td>Colton and Alevizon (1983a)</td>
</tr>
<tr>
<td>Deep Water Cay</td>
<td>25-69 cm FL</td>
<td>393</td>
<td>Not stated</td>
<td>Diet</td>
<td>Colton and Alevizon (1983b)</td>
</tr>
<tr>
<td>San Salvador</td>
<td>51.2 ± 1.4 cm TL SE</td>
<td>17</td>
<td>Angling</td>
<td>Post-release mortality</td>
<td>Cooke and Philipp (2004)</td>
</tr>
<tr>
<td>Eleuthera</td>
<td>48.2 ± 5.0 cm TL SD</td>
<td>87</td>
<td>Angling</td>
<td>Post-release mortality</td>
<td>Danylchuk et al., unpub.</td>
</tr>
<tr>
<td>Eleuthera</td>
<td>50.0 ± 8.4 cm TL SD</td>
<td>14</td>
<td>Seine</td>
<td>Post-release mortality</td>
<td>Danylchuk et al., accepted</td>
</tr>
<tr>
<td>Turks and Caicos Is.</td>
<td>28-72 cm TL</td>
<td>120</td>
<td>Angling, seine</td>
<td>Movement</td>
<td>Clark and Danylchuk (2003)</td>
</tr>
</tbody>
</table>
FIGURE CAPTIONS

Figure 1. Proportion of immigration departure cards collected throughout The Bahamas in 2004 whose respondents indicated that a purpose of their visit was ‘bone/fly fishing’ (n=5000, Government of The Bahamas, unpublished data).