Scientific Review of the Marine Reserve Network Proposed for the Commonwealth of the Bahamas by the Bahamas Department of Fisheries

by

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1. EXECUTIVE SUMMARY

- In July 1999, a panel of three experts on the ecology of Bahamian sea life was invited to provide an external review of the scientific validity of a list of marine reserve sites proposed by the Bahamas Department of Fisheries.

- Ultimately, 39 potential reserve sites were evaluated: 32 from a November 1998 workshop, 2 additional sites proposed by the Bahamas National Trust, 2 sites proposed by the Minister of Agriculture and Fisheries, 2 sites proposed by the scientific review panel, and for comparison, the existing Exuma Cays Land and Sea Park.

- Although currently healthy, Bahamian marine resources are starting to show signs of overconsumption and degradation that have become severe in the Florida Keys and throughout much of the Caribbean. The time for preventative measures is now.

- The Precautionary Principle dictates that a network of permanent no-take marine reserves is the most effective way to ensure long-term sustainability of Bahamians fisheries, to enhance nonconsumptive socioeconomic benefits, and to conserve marine resources for future generations.

- Both empirical and theoretical studies around the world indicate that permanent no-take reserves are most effective when they are large, numerous, evenly dispersed geographically, include a variety of habitats essential for healthy populations of sea life, and are protected from habitat degradation.

- Meeting with the Bahamas National Trust and the Bahamas Reef Environment Educational Foundation, and working closely with the Bahamas Department of Fisheries, the scientific review panel developed rating criteria for prioritizing the proposed reserve sites. Socioeconomic criteria included impacts on fishing activities, potential for community participation, and local community benefits. Ecological criteria focused on two factors: (1) habitat diversity, particularly coral reefs, seagrass beds, and mangroves known to be important for juveniles and adults of economically important species (conch, crawfish, and grouper); and (2) potential to augment regional populations of sea life via larval dispersal.

- Fourteen sites (including the Exuma Cays Land and Sea Park) earned high priority ratings in both socioeconomic and ecological criteria, and were evenly distributed throughout the Bahamas. These sites were judged by the panel to provide the bare minimum for a functional network of permanent no-take reserves.

- The primary recommendations of the panel are that (1) all proposed sites listed on Table 1, except four low-rated sites, be legally designated as permanent no-take marine reserves as soon as possible, and (2) because only two sites contain grouper spawning sites, all spawning aggregations be designated as no-take during the spawning season. The panel also encourages public education to enhance compliance with the no-take regulation.

- The panel further recommends that (1) the government of the Bahamas encourage scientific research on the function and efficacy of the reserve network, and (2) the implementation of this reserve network be considered a first step toward eventual protection of at least 20% of the productive shelf edge of the Bahamas banks.

2. INTRODUCTION

2.1 Background of this review

In November 1998, the Bahamas Reef Environment Educational Foundation sponsored a workshop to discuss the creation of a network of marine reserves for the entire Bahamas archipelago. Workshop participants included 14 elected local government officials representing nearly all of the Family Islands, the Director and Deputy Director of Fisheries, and several fisheries officers from Nassau and Grand Bahama. Dr. Dahlgren, a marine reserve expert from the Center for Marine Conservation, lectured and led discussions related to the need for no-take marine reserves in the Bahamas, their benefits, and criteria for selecting sites and designing a network of marine reserves. Groups of workshop participants then proposed several alternative marine reserve networks, which were subsequently consolidated into a single marine reserve proposal based on the advice of the local officials and under the guidance of the Director of Fisheries. This proposal was then submitted to the Minister of Agriculture and Fisheries for consideration.

In July 1999, the Bahamas Department of Fisheries invited an external panel of experts to evaluate the scientific merit of the proposed network of marine reserves. The review panel, whose biographical sketches appear at the end of this report, comprised an expert on the ecology of Bahamian conch (Dr. Stoner), an expert on marine reserves and the ecology of Bahamian reef fishes (Dr. Hixon), and an expert on marine reserves and the ecology of Bahamian Nassau grouper (Dr. Dahlgren). The Minister of Agriculture and Fisheries personally instructed the panel to review the benefits of no-take reserves, develop objective criteria for evaluating the proposed reserves, and produce a prioritized list of reserve sites. The panel met with representatives of both the Bahamas National Trust and the Bahamas Reef Environment Educational Foundation, and worked closely with the Bahamas Department of Fisheries while preparing this report. Members of the panel have personally examined 29 of the 38 reserve sites reviewed in this report, and additional site visits are planned in the near future.

2.2 Value of Bahamian marine resources

> "Of all the beautiful sights I saw from the spacecraft, the waters of the Bahamas stick in my mind as the most spectacular of all." --Russell Schweickart, APOLLO IX, 1969

The Bahamas are known worldwide as one of the most beautiful places on Earth. Especially attractive to visitors are the multihued waters surrounding the islands and the stunning coral reefs and sea life they support. The sea also provides major local fisheries for crawfish (*Panulirus argus*), conch (*Strombus gigas*), and a variety of finfish, especially Nassau grouper (*Epinephelus striatus*) (MacAlister, Elliot, and Partners 1998). In terms of employment and social importance, fishing is probably second only to tourism in the Bahamas.

From an ecological perspective, the Bahamas Banks comprise the largest area of productive shallow water in the tropical Western Atlantic. The large Exclusive Economic Zone of the Bahamas encompasses a broad variety of marine habitats, including mangroves, seagrass beds, algal beds, coral reefs, and deep-sea areas. These habitats support a rich diversity of sea life, making the Bahamas a major center of tropical and subtropical marine biodiversity in the Atlantic (Birkeland 1996). **Importantly, marine ecosystems of the Bahamas have thus far been spared the major degradation suffered by other tropical marine regions, but the risk is growing.**

2.3 Threats to Bahamian marine resources

> "Fifty-eight percent of the world's reefs are potentially threatened by human activity....Outside of the Pacific, 70 percent of all reefs are at risk." --*Reefs at Risk* (Bryant et al. 1998)

The Caribbean is one of the most degraded tropical marine regions in the world. Almost two-thirds of the reefs here are at risk, including about one-third at high risk (Bryant et al. 1998). Major threats include poorly planned coastal development, pollution, and overfishing. Outside the Bahamas, numerous spawning aggregations of Nassau grouper and other species have been fished to extinction (Domeier and Colin 1997). Overfishing of herbivorous fishes, combined with a mass mortality of sea urchins, has contributed to the death of reefs due to seaweeds smothering corals (Hughes 1994). Immediately adjacent to the Bahamas, the marine ecosystems of the Florida Keys are severely degraded (Bryant et al. 1998). **The demise of Florida's reefs is a disturbing warning of what could happen to the Bahamas unless preventative measures are taken.**

Although the Bahamas are still relatively unscathed, negative human impacts are growing. Shallow waters near New Providence and other population centers suffer from coastal development and pollution. There is evidence that crawfish stocks have reached a point of economic overexploitation (MacAlister, Elliot, and Partners 1998), and at least two Nassau grouper spawning aggregations have been fished to extinction (Bahamas Department of Fisheries). Despite fishing regulations, there is substantial illegal harvesting and poaching (MacAlister, Elliot, and Partners 1998). As the local population expands and foreign interest in the Bahamas increases, especially by developers, human impacts on Bahamian marine systems are bound to worsen.

2.4 Principles of no-take marine reserves

The concept of marine reserves in which all extractive activities are forbidden is based on the "*Precautionary Principle*" (Ludwig et al. 1993), which can be summarized by two statements: (1) fisheries should be managed with a margin of safety to allow for environmental variability, unforeseen events, and limited data; and (2) insufficient data is not a valid reason for postponing management decisions. The Precautionary Principle evolved in response to the limited success of conventional fisheries management and the fact that marine fisheries worldwide are collapsing (Safina 1995). Conventional management practices have failed because of inadequate data, limited understanding of the biology and ecology of the target species, the multispecies nature of most fisheries (including reef fisheries—Polunin and Roberts 1996), problems with environmental variability, and political forces setting fishing quotas higher than advised by biologists. The Precautionary Principle provides a basis for recent international declarations on fisheries and conservation (e.g., the Rio Declaration, the FAO Code of Conduct on Responsible Fisheries).

No-take marine reserves are superbly in accordance with the Precautionary Principle in that they ensure that a portion of fishery stocks—as well as the habitats and ecosystems that support them—remain undisturbed by human activities. There are numerous benefits of no-take reserves that are not provided by other management strategies.

2.5 Benefits of no-take marine reserves

Permanent no-take marine reserves have proven to be highly effective at benefiting fisheries and local economies, especially in tropical regions. Additionally, there are sound theoretical reasons why networks of these reserves should propagate regional populations of sea life. These benefits have led to increasing use of networks of reserves as a fisheries conservation tool, including networks currently being planned in Hawaii and California.

2.5.1 Documented fisheries benefits

Empirical evidence on the effectiveness of no-take marine reserves has focused on fisheries (reviews by Roberts and Polunin 1991, 1993, Dugan and Davis 1993, Rowley 1994, Roberts 1995, Russ and Alcala 1996, Bohnsack 1998, 1999, Murray et al. 1999). These documented benefits are numerous:

- **Larger and more abundant fish and invertebrates within reserves:** This pattern is very well-documented worldwide, including in the existing Exuma Cays Land and Sea Park (Sluka et al. 1996, Stoner and Ray 1996).

- **Spillover of fish into adjacent non-reserve areas:** With a build-up in fish abundance in reserves, larger fish cross reserve boundaries and are taken by fishermen, thus enhancing local fisheries. No-take ensures that population sizes in reserves reach levels that cause this "***spillover effect***," as documented in the Exuma Cays Land and Sea Park (Sluka et al. 1996). The spillover effect is particularly beneficial when the boundary of a reserve is readily accessible by the local community.

- **Protection of large spawners:** Fishing selectively removes larger individuals from a population. Populations within no-take reserves contain more large individuals, which produce more offspring and thus contribute disproportionately to the population.

- **Protection of marine habitats:** Fishing activities and gears may damage marine habitats (e.g., hauling lines of traps through corals on the drop-off). No-take prevents such damage.

- **Protection against population changes:** Fishing may cause genetic changes, sex ratio changes, or behavioral changes by selectively targeting larger individuals, especially when spawning aggregations are targeted (Domeier and Colin 1997). Stocks are protected from these problems only in no-take areas.

- **Protection of biodiversity and ecosystem structure and function:** Marine ecosystems are poorly understood, and overfishing of certain species—such as crawfish and grouper—may in the long term put ecosystems out of balance. For instance, the excessive removal of seaweed-eating urchins and fishes in Jamaica contributed to severe degradation of coral reefs (Hughes 1994). In the Bahamas, removal of predatory fish, such as grouper, may destabilize populations of other fish (Hixon and Carr 1997).

2.5.2 Theoretical fisheries benefits

Besides the above effects, the documented increase in egg production within no-take reserves may result in a regional "*seeding effect*." That is, developing eggs and larvae, which drift in ocean currents, may settle and grow not only in reserve areas, but also in many habitats downstream, thus benefiting the larger region (Ballantine 1995, Sladek Nowlis and Roberts 1997, 1999, Murray et al. 1999). A ***network*** of reserves, spread uniformly and closely over a broad geographic area, would thus ensure that an entire region like the Bahamas archipelago is replenished with young grouper, crawfish, and conch. The seeding effect has not yet been demonstrated empirically because networks of marine reserves are a relatively new concept. However, the theoretical arguments are compelling.

2.5.3 Nonconsumptive benefits

Besides benefits to fisheries, no-take marine reserves provide two major nonconsumptive benefits:

- **Enhanced economic benefits:** Undisturbed marine parks provide economic benefits from ecotourism, recreational diving, catch-and-release fishing (e.g., bonefish, where permitted), and other nonextractive water activities.

- **Education:** No-take reserves provide an excellent base for public and visitor education about marine ecosystems and conservation.

2.5.4 Additional social and scientific benefits

Finally, no-take marine reserves provide a variety of noneconomic benefits:

- **Public understanding and acceptance:** No-take is a relatively simple concept that may be more easily accepted than other fisheries management regulations, especially given the general acceptance of the idea of land parks and reserves.

- **Fairness:** Marine reserves are an equitable management strategy that does not favor any particular group of consumptive users.

- **Simplified enforcement:** Geographically restricted areas are easier to police, and easier to target for compliance based on public education.

- **Reduced fisheries data needs:** In accordance with the Uncertainty Principle, detailed information on populations and ecosystems is not required for no-take reserve design and management. Note, however, that no-take marine reserves cannot provide a complete substitute for other forms of fisheries management. No-take reserves should be regarded as an addition to rather than a replacement for existing fishery management practices (Allison et al. 1998).

- **Fisheries and marine biological research:** Marine reserves provide "control" sites, allowing scientists to examine the effects of fishing on target species, separate the long-term effects of fishing vs. environmental variation, and conduct broad marine research in undisturbed areas.

2.6 Design criteria for no-take marine reserve networks

Beyond the core concept of no-take, general design criteria for marine reserves are well-documented (Ballantine 1995, Bohnsack 1998, 1999, Murray et al. 1999). The criteria listed below correspond closely with those developed by both the Bahamas National Trust and the U.S. Coral Reef Task Force. Each of the criteria listed in this section was considered by the scientific review panel while evaluating the proposed sites of marine reserves in the Bahamas (see Section 3).

2.6.1 Individual reserves

For each no-take marine reserve, the following design criteria are important:

- **State explicit goals**, including both socioeconomic and ecological perspectives. The evaluation criteria used in this report incorporate the goal of enhancing fisheries and other socioeconomic benefits while conserving marine resources in accordance with sound ecological principles.

- **Make the reserve permanent.** Previous experience has shown that reserves are rapidly decimated when opened, due to disproportional targeting by fishermen. The benefits of no-take reserves accrue from their permanence.

- **Make the reserve large enough** to include juvenile and adult home ranges of target species. For conch, crawfish, and grouper in the Bahamas, home ranges over the juvenile and adult life span are up to 10's of kilometers (personal observations of scientific review panel).

- **Include a mixture of habitats** for target species, including areas for larval settlement, juvenile survival and growth (nursery habitat), and adult activities (especially spawning). In the Bahamas, conch larvae settle in shallow sandy habitats on the shelf edge, and lobster and Nassau grouper larvae settle in algal beds near mangroves before moving to reefs (personal observations of scientific review panel).

- **Include habitats critical for population conservation**, such as spawning aggregation sites (prominent shelf-edge features for grouper and muttonfish) and nursery habitats (mangroves, seagrass beds, and patch reefs).

- **Avoid traditional high use areas** or areas which may result in economic hardships for fishermen.

- **Locate reserves close to fishing grounds** for maximum benefit from the spillover effect (see Section 2.5.1).

- **Locate reserves where nonconsumptive use** is economically beneficial.

- **Locate reserves near monitoring and enforcement sites** (e.g., supportive communities, scientific research stations, nonconsumptive users, fisheries and enforcement officials).

- **Avoid areas with non-fisheries environmental problems** (e.g., heavy development of nearby land areas, pollution, sedimentation, habitat degradation), and protect the reserve from future degradation.

- **When possible, use conspicuous geographic features to define reserve boundaries**, which facilitates compliance.

2.6.2 Networks of reserves

The seeding effect of no-take reserves (see Section 2.5.2) depends on several design criteria:

- **Place reserves both upstream and downstream from each other—as well as close to each other and to fished non-reserve sites**—in order to maximize the probability of population connectivity via larval dispersal. This criterion is ensured by broadly uniform dispersion of numerous reserves.

- **Include all representative habitats and environmental conditions in each region.** The Little Bahama Bank, the Great Bahama Bank, and the southern islands form fairly distinctive geographic regions.

- **Include replicate sites of each representative habitat within each region.** This criterion is in accordance with the Precautionary Principle as insurance against the unanticipated loss of a reserve (e.g., due to a chemical spill, coral bleaching, etc.).

- **To ensure that marine reserve networks are effective, it has been suggested that a long term goal should be to include 10-30% of all ecologically important habitats** (IUCN 1992, Roberts et al. 1995, Bohnsack 1998, WWF 1998).

3. METHODS

Thirty-nine sites were evaluated for value as marine reserves: 32 proposed at the November 1998 workshop, 2 suggested by the Minister of Agriculture and Fisheries, 2 suggested by the Bahamas National Trust, 2 additional sites suggested by the scientific review panel, and the Exuma Land and Sea Park for comparison. Also, alternate reserve boundaries were considered for four of the sites, making a total of 43 site evaluations. Site evaluation, scoring, and prioritization was conducted on the basis of two criterion types: socioeconomic and ecological. Each criterion was scored from 1 (low benefit) to 3 (high benefit). Sources of information for socioeconomic factors included staff at the Department of Fisheries and local representatives who participated in the aforementioned workshops. Ecological criteria were scored on the basis of maps and charts, the review panel's personal knowledge of the sites, and flyovers. Twenty-

nine of the 39 sites (74%) of the sites had been examined by the panel members by the time this report, with additional site visits planned in the near future.

3.1 Socioeconomic Criteria

Community impacts, participation, and benefits were scored with respect to effects on the human population in the immediate vicinity of each proposed marine reserve. Impacts on distant fishing fleets needed to be considered for certain important fishing grounds.

3.1.1 Fishing Impact

Displacement of current fishing activities was considered to be a short-term negative effect of establishing a marine reserve. Scores were dependent upon the existing level of fishing in the area, the size of the human population in or surrounding the proposed reserve, and the presence or absence of alternative fishing grounds nearby. High impact was scored 1, moderate impact was scored 2, and low effect was scored 3.

3.1.2 Community Participation

Community involvement in the development and supervision of a marine reserve was considered a desirable feature for a proposed site. A score of 3 was assigned if local populations including land owners have voiced support for instituting a reserve. Scores of 2 were given to sites where there is a community nearby, but the local support for a marine reserve is unknown. Sites with no community nearby were scored 1.

3.1.3 Community Benefits

Positive economic effects on the community surrounding a proposed marine reserve could accrue from at least two sources. Diverse forms of income from marine reserves would include nonconsumptive activities such as ecotourism, recreational diving, catch-and-release fishing (where permitted), and other water activities guided by local residents. Also, it is likely that some reserves help to support continued, or even enhanced, fishery yields in the waters surrounding the reserves due to the spillover effect of reserves (see Section 2.5.1). A score of 3 was assigned when the potential for both nonconsumptive and spillover effects was high. Scores of 2 were given when these benefits were considered to be moderate, and scores of 1 were assigned when the positive effects were likely to be low, due to either the remote location of a reserve or expected low indirect economic benefit to the local community.

A supplement score of 3 was added when there was a specific sociopolitical uniqueness associated with a site. This criterion included proposed sites adjacent to existing parks, research laboratories, or educational facilities.

3.2 Ecological Criteria

Relative ecological value of a proposed marine reserve was scored on the basis of two primary criteria: habitat diversity and regional importance as a potential source of larvae for seeding surrounding waters of the Bahamas.

3.2.1 Habitat Diversity

Habitat diversity was considered to be a highly desirable characteristic of a proposed marine reserve, given that different nominal habitat types such as mangroves, seagrass beds, algal beds, and coral reefs support the different life history stages of economically significant species such as grouper, lobster and conch (see Section 2.6.1). Sites with healthy reef, seagrass and mangrove habitats were scored 3, while highly degraded locations and sites characterized primarily by bare sand were scored 1. Sites with healthy reef environment only, or sites with two of the three key habitats were assigned a score of 2. Large proposed reserves tended to have higher habitat diversity than small ones, but this was not always the case.

3.2.2 Regional Importance

One of the important ecological benefits of marine reserves is the support of reproductive populations for economically significant species and the associated seeding effect of larval export to surrounding waters both close to and distant from the reserve (see Section 2.5.2). Larvae are dispersed by oceanic currents. The complexity of currents in the Bahamas archipelego is immense including many gyres and eddies. However, the net prevailing current runs from the southeast to the northwest. Relative regional importance of each reserve site was scored from 1 to 3 on the basis of low, medium, and high potential for larval export to other areas in the Bahamas. High scores were generally assigned to sites with potential for high total spawner biomass (i.e., high density and/or large reserve size) coupled with generally upstream location in the Bahamas archipelago (i.e., southeast position in the southeast-to-northwest alignment of the islands).

A supplemental score for ecological uniqueness was added where the proposed reserve contained either an important spawning aggregation site (usually Nassau grouper) or some habitat feature not common in the Bahamas. These included special reef formations (atolls, pinnacles, and barrier reefs), exceptional stands of uncommon corals (*Acropora* spp.) that are currently proposed for endangered species status, and concentrations of marine blue holes.

3.3 Geographical Considerations

The sites were categorized according to their locations in the Northern, Central, Southern, and Western Bahamas, because of the desire to establish a geographically dispersed network of marine reserves throughout the archipelago (see Section 2.6.1). The Northern locations were those on the Little Bahama Bank. Central sites were generally those attached to the Great Bahama Bank, and Southern sites included a site in the Ragged Island Chain and all of those south and east of the Crooked Island Passage. Cay Sal Bank was the only site in the Western Bahamas grouping.

3.4 Calculation of Overall Scores and Priority Ratings

Overall scores for the proposed marine reserve sites were calculated by averaging the individual socioeconomic scores (3 or 4 columns, see Table 1), averaging the individual scores for ecological criteria (2 or 3 columns), and adding the two values. The total priority score, therefore, could range from 2 (lowest priority) to 6 (highest priority).

4. RESULTS

Total priority scores for the 43 proposed reserves, including alternate boundary definitions for four of the sites, ranged from 2.67 (lowest) to 5.67 (highest) (Table 1 and maps). Five sites had scores greater than 5.0, scoring high on the basis of both socioeconomic and ecological criteria. One of the highest scores (5.5) went to the Exuma Cays Land and Sea Park (Site No.14), so it is clear that this was a good choice for the first marine reserve in the Bahamas. North Long Island at Cape Santa Maria (Site No. 21), Lee Stocking Island (Exuma Cays)(Site No. 19), the northwest section of Great Inagua (Site No. 30), and Central Andros (Site No. 9b) also fell into this highest priority category.

Eight sites scored 5.0 overall. All of these sites had high scores on the basis of both socioeconomic and ecological criteria. Two sites were newly proposed by the scientific review panel because of their exceptional ecological value: the eastern shore of Cat Island (Site No. 34) and a southeast section of South Andros (Site No. 35). Northwest Crooked Island (Site No. 26), northeast Acklins (Site No. 27), and Conception Island (Site No. 22) also received scores of 5.0 because of their high habitat diversity and potential role in contributing larvae to surrounding areas.

Three other sites received 5.0 priority ratings when the scientific review panel expanded the boundaries of the proposed reserves to include areas of special interest. These sites were, therefore, evaluated both as originally proposed and as expanded alternates. Most notably, when the small Frozen/Alder Cays area (Site No. 8(i)) was expanded south to include large reef habitats near Whale Cay (Site No. 8(ii)), the overall score increased from 3.5 to 5.0. Expansion of the Pelican Cays (Abaco) site (Site No. 5(i)) to include Little Harbour (Site No. 5(ii)) resulted in a score increasing from 4.25 to 5.0, because of the inclusion of a very unique set of 24 marine blue holes in the inner Little Harbour region. A smaller increase (4.75 to 5.0) also occurred by expanding the Powell Point (Eleuthera) site (Site No. 13(i)) to include the Schooner Cays (Site No. 13(ii)). The expansion added a very important nursery ground for both queen conch and spiny lobster, but impact on the fishing community also increased.

A proposed expansion of the northern Abaco site at Walkers Cay (Site No. 1(i)) did not improve the total priority score. When Grand Cay was added to Walkers Cay (Site No. 1(ii)), the ecological factor increased, the socioeconomic factor decreased, and the overall score remained constant at 4.25. Also, when the site southwest of New Providence Island was considered both with (Site No. 10a(ii)) and without (Site No. 10a(i)) a total no-take provision, the overall scores were nearly equal because of the compromise between socioeconomic and ecological effects.

Ten sites received overall scores lower than 4.0. Most of these resulted from relatively low ratings for ecological criteria because of low habitat diversity and/or small reserve size. Examples are Peterson Cay (Grand Bahama) (Site No. 2), Sandy Cay (Long Island) (Site No. 25), Frozen/Alder Cay (Berry Islands) without the southern extension (Site No. 8(i)), and the Sea Garden (east New Providence Island) (Site No. 10b). This latter site, located just east of the Nassau Harbour, is highly impacted by human activity, is a very small area, and would have little community benefit or regional significance as a larval source. Some large areas not scoring high were the Marls in the Bight of Abaco (Site No. 4) because of low habitat diversity and low potential community participation and benefit, and the Old Bight of Cat Island (Site No. 18) because of low habitat diversity, low potential for regional importance, and low community benefit.

There were some general differences in the overall scores of sites when considered by geographic region. All of the sites in the southern region had scores over 4.3 because of their high ecological significance related to both high habitat quality and diversity, and because of high potential for exporting larvae to downstream populations. Scores for sites in the central region were highly variable, but most were higher than or equal to 4.0. Most of the low ecological scores were associated with small reserves and/or low habitat diversity such as that found along the west shores of Cat Island (Site No. 17) and Eleuthera (Site No. 13(i)). Northern sites scored generally lower than more southerly sites because of lower potential as larval sources for the rest of the Bahamas and, in many cases, small reserve size. Nevertheless, scores for socioeconomic factors tended to be high, and northern sites may be more easily developed and managed as reserves. Cay Sal Bank, the most extreme western site considered, had a relatively low overall score (4.0) because of low potential for community participation and benefit, and uncertainty about the role of the Bank as a larval source for other regions of the Bahamas. However, the Cay Sal Bank (Site No. 33) probably provides a very large nursery ground for fishery species and is an important nesting site for sea turtles.

5. RECOMMENDATIONS

"In the end, we will protect only what we love." --Senegalese poet and naturalist Baba Dioum

With its beautiful, bountiful, and extensive marine ecosystems still largely intact, the Commonwealth of the Bahamas is in a prime position to save its marine resources for future generations. By implementing a network of permanent no-take marine reserves as soon as possible, the Bahamas will provide the world with a showcase approach to enlightened management of ocean resources. With these ideals in mind, the *primary recommendations* of the scientific review panel are threefold:

- **The panel recommends that all proposed sites listed on Table 1, except those four sites having a total priority score less than 3.5, be legally designated as permanent no-take marine reserves as soon as possible. The Precautionary Principle (see Section 2.4) dictates that lack of detailed scientific data is not a valid excuse for delaying action crucial for effective conservation of valuable marine resources.**

- **No matter which sites are designated, the panel recommends that the marine reserves should be permanent, no-take, numerous, large, include a diversity of habitats essential for the life cycles of important sea life, protect those habitats, and provide broad geographic representation.**

- **Because the proposed reserves include only two grouper spawning aggregation sites out of nearly 30 known to exist in the Bahamas, the panel recommends that all spawning aggregation sites be designated as no-take throughout the entire reproductive season (November – March).**

There are two important *steps toward implementing these recommendations*:

(1) **Immediate legal designation as permanent no-take reserves of at least the 13 sites of highest priority** (total priority score of 5.0 or greater):

Abaco – Pelican Cays to Little Harbour (site 5(ii))
Berry Islands – Frozen Cay to Whale Cay (site 8(ii))
Andros – Central (site 9b)
Eleuthera Island – Powell Point to Schooner Cays (site 13(ii))
Exuma Cays – Lee Stocking Island and vicinity (site 19)
Long Island – North (site 21)
Conception Island (site 22)
San Salvador – Northeast (23(ii))
Crooked Island – Northwest (site 26)
Acklins – North (site 27)
Great Inagua – North (site 30)
Cat Island – East (site 34)
Andros – South (site 35)

The panel judges that these sites meet the minimal criteria for a functional network of permanent no-take marine reserves.

(2) **Expanded education and involvement of communities near these sites.** Experience outside the Bahamas has shown that voluntary compliance is far more effective than enforcement in successfully implementing marine reserves.

Looking to the future, we view this plan as an initial conservation effort. The reefs and associated habitats along the shelf edge of the Bahamas banks support most of the essential resources for valuable marine species in the Bahamas (see Section 2.6.1). In accordance with published recommendations (see Section 2.6.1), the panel suggests two *follow-up actions*:

(1) **The government of the Bahamas facilitates scientific research on the function and efficacy of the national network of marine reserves.**

(2) **The national network of marine reserves ultimately is expanded to include at least 20% of the total shelf edge of the Bahamas banks containing reefs and associated habitats.**

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Table 1 Legend

Region

N = Northern Bahamas (Little Bahamas Bank)
C = Central Bahamas (most of Great Bahamas Bank)
S = Southern Bahamas (Ragged Islands and islands south of Crooked Islands Channel)

Socioeconomic criteria

Fishing impact:
1 = High displacement of fishing activity
2 = Moderate displacement of fishing activity
3 = Low displacement of fishing activity

Community participation:
1 = No community nearby
2 = Community nearby, support uncertain
3 = Supportive community nearby

Community benefits (see Section 2.5):
1 = Low nonconsumptive benefits and spillover effect
2 = Moderate nonconsumptive benefits and/or spillover effect
3 = High nonconsumptive benefits and/or spillover effect

Ecological criteria

Habitat diversity:
1 = Habitat sparse or degraded by human activities
2 = Healthy reef, reef/seagrass, reef/mangrove, seagrass/mangroves
3 = Healthy reef, seagrass and mangrove

Regional importance:
1 = Low potential source of larvae for the Bahamas
2 = Moderate potential source of larvae for the Bahamas
3 = High potential source of larvae for the Bahamas

Table 1: Priority ranking of proposed marine reserves

Site No.	Site	Region	Socioeconomic Criteria					Ecological Criteria				Composite Scores		
			Fishing Impact	Community Participation	Community Benefits	Sociopolitical Uniqueness	Uniqueness Comments	Habitat Diversity	Regional Importance	Ecological Uniqueness	Uniqueness Comments	Socio-economic Average Score (1-3)	Ecological Average Score (1-3)	Total Priority Score (2-6)
5(ii)	Abaco - Pelican Cays to Little Harbour	N	2	2	3	3	existing land/sea park	3	2	3	24 marine blue holes in Little Harbor	2.50	2.67	5.17
3	Abaco - Nun Jack Cay/Green Turtle Cay	N	2	2	3			3	1			2.33	2.00	4.33
1(i)	Abaco - Walkers Cay	N	2	3	3	3	already underway	2	1			2.75	1.50	4.25
1(ii)	Abaco - Walkers Cay and Grand Cay	N	1	2	3	3	already underway	3	1			2.25	2.00	4.25
5(i)	Abaco - Pelican Cays	N	2	3	3	3	existing land/sea park	2	1			2.75	1.50	4.25
31	Grand Bahama - Sweetings Cay	N	1	2	2			3	2			1.67	2.50	4.17
2	Grand Bahama - Peterson Cay	N	3	2	1	3	existing land park	2	1			2.25	1.50	3.75
32	Grand Bahama - North	N	3	1	1	3	existing land park	1	1	3	unique cave system	2.00	1.67	3.67
4	Abaco - The Marls	N	3	1	1			1	1			1.67	1.00	2.67
21	Long Island - North	C	2	3	3			3	3	3	grouper spawning aggregation nearby	2.67	3.00	5.67
14	Exuma Cays Land and Sea Park	C	2	2	3	3	existing land/sea park	3	3			2.50	3.00	5.50
19	Exuma Cays - Lee Stocking Island	C	2	3	2	3	research center	3	3			2.50	3.00	5.50
9b	Andros - Central	C	2	3	3	3	already underway	3	2			2.75	2.50	5.25
23(ii)	San Salvador - Northeast	C	3	3	2	3	field station	3	2			2.75	2.50	5.25
8(ii)	Berry Islands - Frozen Cay to Whale Cay	C	1	3	2			3	3			2.00	3.00	5.00
13(ii)	Eleuthera - Powell Point/Schooner Cays	C	1	2	2	3	Island School	3	3			2.00	3.00	5.00
22	Conception Island	C	3	1	1	3	existing land park	3	3	3	barrier reef and coral pinnacles	2.00	3.00	5.00
34	Cat Island - East	C	3	2	2			3	2	3	abundant *Acropora* corals	2.33	2.67	5.00
35	Andros - South	C	2	2	2			3	3	3	grouper spawning aggregation	2.00	3.00	5.00
11	Eleuthera - Harbour Island	C	2	2	3			3	2			2.33	2.50	4.83
24	Rum Cay	C	3	2	2			3	2			2.33	2.50	4.83
13(i)	Eleuthera - Powell Point	C	2	2	2	3	Island School	2	3			2.25	2.50	4.75
9a	Andros - Joulter Cays	C	1	2	2			3	3			1.67	3.00	4.67
23(i)	San Salvador - West	C	3	2	2			2	2			2.33	2.00	4.33
10a(ii)	New Providence - SW reef (no take)	C	1	2	2			2	3	3	muttonfish spawning aggregation	1.67	2.67	4.33
10a(i)	New Providence - SW reef (as proposed)	C	3	3	2	3	already underway	2	1			2.75	1.50	4.25
16	Little San Salvador	C	2	2	1			3	2			1.67	2.50	4.17
6	North Bimini - East	C	3	3	1	3	research lab	2	1			2.50	1.50	4.00
12	Eleuthera - East	C	3	2	1			2	2			2.00	2.00	4.00
20	Great Exuma - Jewfish Cays	C	3	2	1			2	2			2.00	2.00	4.00
7	Cat Cay	C	3	3	1			2	1			2.33	1.50	3.83
15	Green Cay	C	2	1	1			3	2			1.33	2.50	3.83
25	Long Island - Sandy Cay	C	2	2	1			2	2			1.67	2.00	3.67
8(i)	Berry Islands - Frozen/Alder Cay	C	2	3	1			2	1			2.00	1.50	3.50
10b	New Providence - Sea Garden	C	3	3	1			1	1			2.33	1.00	3.33
17	Cat Island - North	C	3	2	1			1	1			2.00	1.00	3.00
18	Cat Island - Old Bight	C	3	2	1			1	1			2.00	1.00	3.00
30	Great Inagua - North	S	3	2	2	3	existing land park	3	3			2.50	3.00	5.50
26	Crooked Island - Northwest	S	2	2	2			3	3	3	grouper spawning aggregation	2.00	3.00	5.00
27	Acklins - North	S	3	1	2			3	3			2.00	3.00	5.00
28	Mayaguana - Pirates' Well	S	3	2	2			3	2			2.33	2.50	4.83
36	Ragged Island Chain - Central	S	3	1	1			3	3			1.67	3.00	4.67
37	Little Inagua	S	3	1	1	3	existing land park	2	3			2.00	2.50	4.50
29	Hogsty Reef	S	3	1	1			2	3	3	only atoll in Bahamas	1.67	2.67	4.33
33	Cay Sal Bank	W	3	1	1			2	2	3	large area/major turtle nesting ground	1.67	2.33	4.00

Table 1: Priority ranking of proposed marine reserves (revised August 1999)

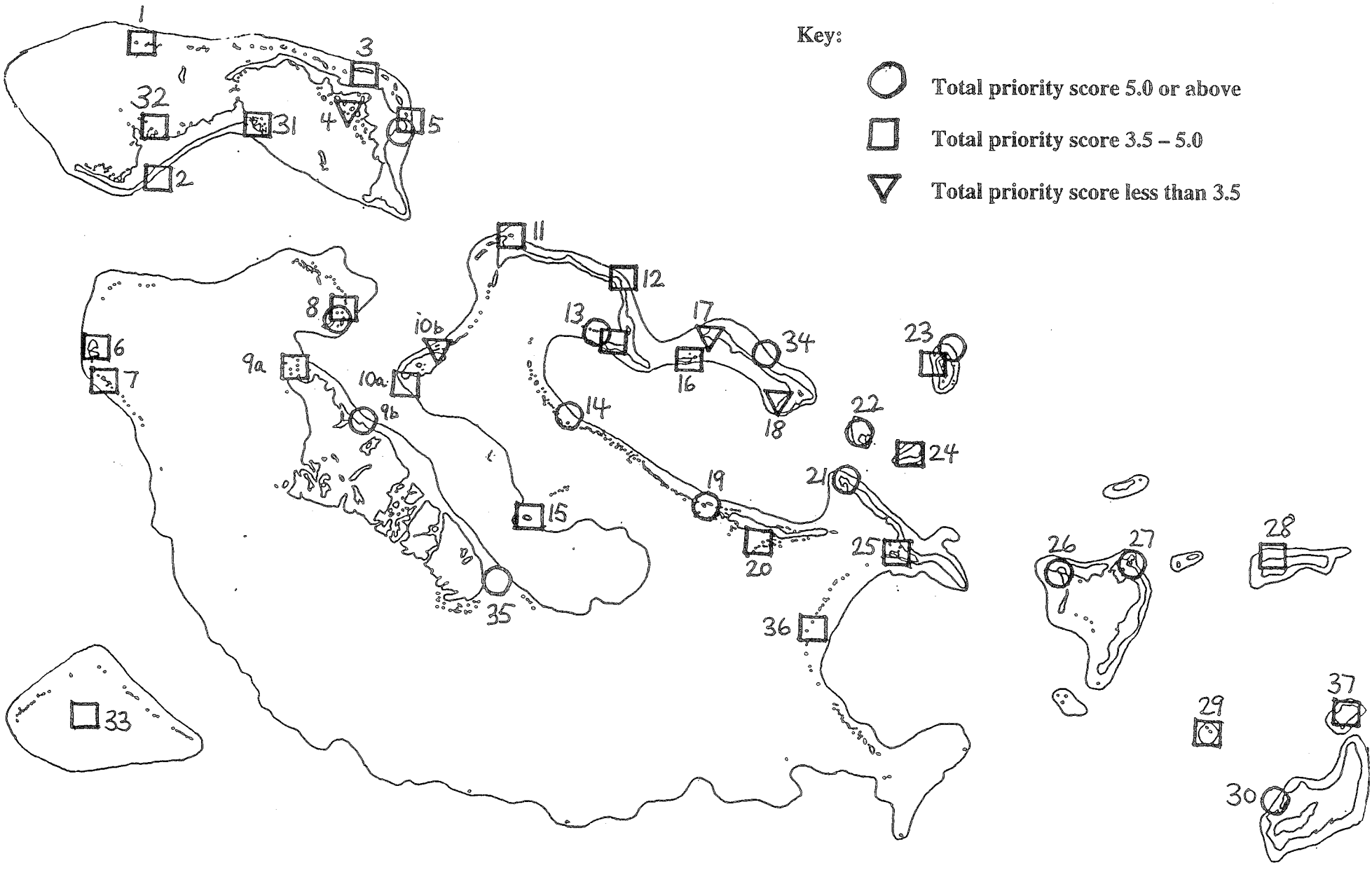
	Site No.	Site	Region	Socioeconomic Criteria					Ecological Criteria				Composite Scores		
				Fishing Impact	Community Participation	Community Benefits	Sociopolitical Uniqueness	Uniqueness Comments	Habitat Diversity	Regional Importance	Ecological Uniqueness	Uniqueness Comments	Socio-economic Average Score (1-3)	Ecological Average Score (1-3)	Total Priority Score (2-6)
	5(ii)	Abaco - Pelican Cays to Little Harbour	N	2	2	3	3	existing land/sea park	3	2	3	24 marine blue holes in Little Harbor	2.50	2.67	5.17
	3	Abaco - Nun Jack Cay/Green Turtle Cay	N	2	2	3			3	1			2.33	2.00	4.33
*	31	Grand Bahama - Sweetings Cay	N	1	2	2			3	2	3	unique Zodiac Caverns	1.67	2.67	4.33
	1(i)	Abaco - Walkers Cay only	N	2	3	3	3	already underway	2	1			2.75	1.50	4.25
	1(ii)	Abaco - Walkers Cay and Grand Cay	N	1	2	3	3	already underway	3	1			2.25	2.00	4.25
	5(i)	Abaco - Pelican Cays only	N	2	3	3	3	existing land/sea park	2	1			2.75	1.50	4.25
	2	Grand Bahama - Peterson Cay	N	3	2	1	3	existing land park	2	1			2.25	1.50	3.75
	32	Grand Bahama - North	N	3	1	1	3	existing land park	1	1	3	unique Lucayan Caverns	2.00	1.67	3.67
	4	Abaco - The Marls	N	3	1	1			1	1			1.67	1.00	2.67
	21	Long Island - North	C	2	3	3			3	3	3	grouper spawning aggregation	2.67	3.00	5.67
	14	Exuma Cays Land and Sea Park	C	2	2	3	3	existing land/sea park	3	3			2.50	3.00	5.50
	19	Exuma Cays - Lee Stocking Island	C	2	2	3	3	research center	3	3			2.50	3.00	5.50
*	20(ii)	Great Exuma - Jewfish Cays/Elizabeth Hbr.	C	3	3	3			3	2			3.00	2.50	5.50
	9b	Andros - Central	C	2	3	3	3	already underway	3	2			2.75	2.50	5.25
	23b	San Salvador - Northeast	C	3	3	2	3	field station	3	2			2.75	2.50	5.25
*	11	Eleuthera - Harbour Island	C	2	3	3			3	2			2.67	2.50	5.17
	8(ii)	Berry Islands - Frozen Cay to Whale Cay	C	1	3	2			3	3			2.00	3.00	5.00
	13(ii)	Eleuthera - Powell Point/Schooner Cays	C	1	2	2	3	Island School	3	3			2.00	3.00	5.00
	22	Conception Island	C	3	1	1	3	existing land park	3	3	3	barrier reef and coral pinnacles	2.00	3.00	5.00
	34	Cat Island - East	C	3	2	2			3	2	3	abundant *Acropora* corals	2.33	2.67	5.00
	35	Andros - South	C	2	2	2			3	3	3	grouper spawning aggregation	2.00	3.00	5.00
*	13(i)	Eleuthera - Powell Point only	C	2	3	2	3	Island School	2	3			2.50	2.50	5.00
	24	Rum Cay	C	3	2	2			3	2			2.33	2.50	4.83
	9a	Andros - Joulter Cays	C	1	2	2			3	3			1.67	3.00	4.67
*	23a	San Salvador - West	C	3	3	2			2	2			2.67	2.00	4.67
	10a(ii)	New Providence - SW reef (no take)	C	1	2	2			2	3	3	muttonfish spawning aggregation	1.67	2.67	4.33
	10a(i)	New Providence - SW reef (as proposed)	C	3	3	2	3	already underway	2	1			2.75	1.50	4.25
	16	Little San Salvador	C	2	2	1			3	2			1.67	2.50	4.17
	20(i)	Great Exuma - Jewfish Cays only	C	3	2	1			2	2			2.00	2.00	4.00
	6	North Bimini - East	C	3	3	1	3	research lab	2	1			2.50	1.50	4.00
	12	Eleuthera - East	C	3	2	1			2	2			2.00	2.00	4.00
	7	Cat Cay	C	3	3	1			2	1			2.33	1.50	3.83
	15	Green Cay	C	2	1	1			3	2			1.33	2.50	3.83
	25	Long Island - Sandy Cay	C	2	2	1			2	2			1.67	2.00	3.67
	8(i)	Berry Islands - Frozen/Alder Cay only	C	2	3	1			2	1			2.00	1.50	3.50
	10b	New Providence - Sea Garden	C	3	3	1			1	1			2.33	1.00	3.33
	17	Cat Island - North	C	3	2	1			1	1			2.00	1.00	3.00
	18	Cat Island - Old Bight	C	3	2	1			1	1			2.00	1.00	3.00
	30	Great Inagua - North	S	3	2	2	3	existing land park	3	3			2.50	3.00	5.50
	26	Crooked Island - Northwest	S	2	2	2			3	3	3	grouper spawning aggregation	2.00	3.00	5.00
	27	Acklins - North	S	3	1	2			3	3			2.00	3.00	5.00
	28	Mayaguana - Pirates' Well	S	3	2	2			3	2			2.33	2.50	4.83
	36	Ragged Island Chain - Central	S	3	1	1			3	3			1.67	3.00	4.67
	37	Little Inagua	S	3	1	1	3	existing land park	2	3			2.00	2.50	4.50
	29	Hogsty Reef	S	3	1	1			2	3	3	only atoll in Bahamas	1.67	2.67	4.33
	33	Cay Sal Bank	W	3	1	1			2	2	3	large area/major turtle nesting ground	1.67	2.33	4.00

* revised from July 1999 report

MAP GUIDE: Proposed marine reserves listed by site number

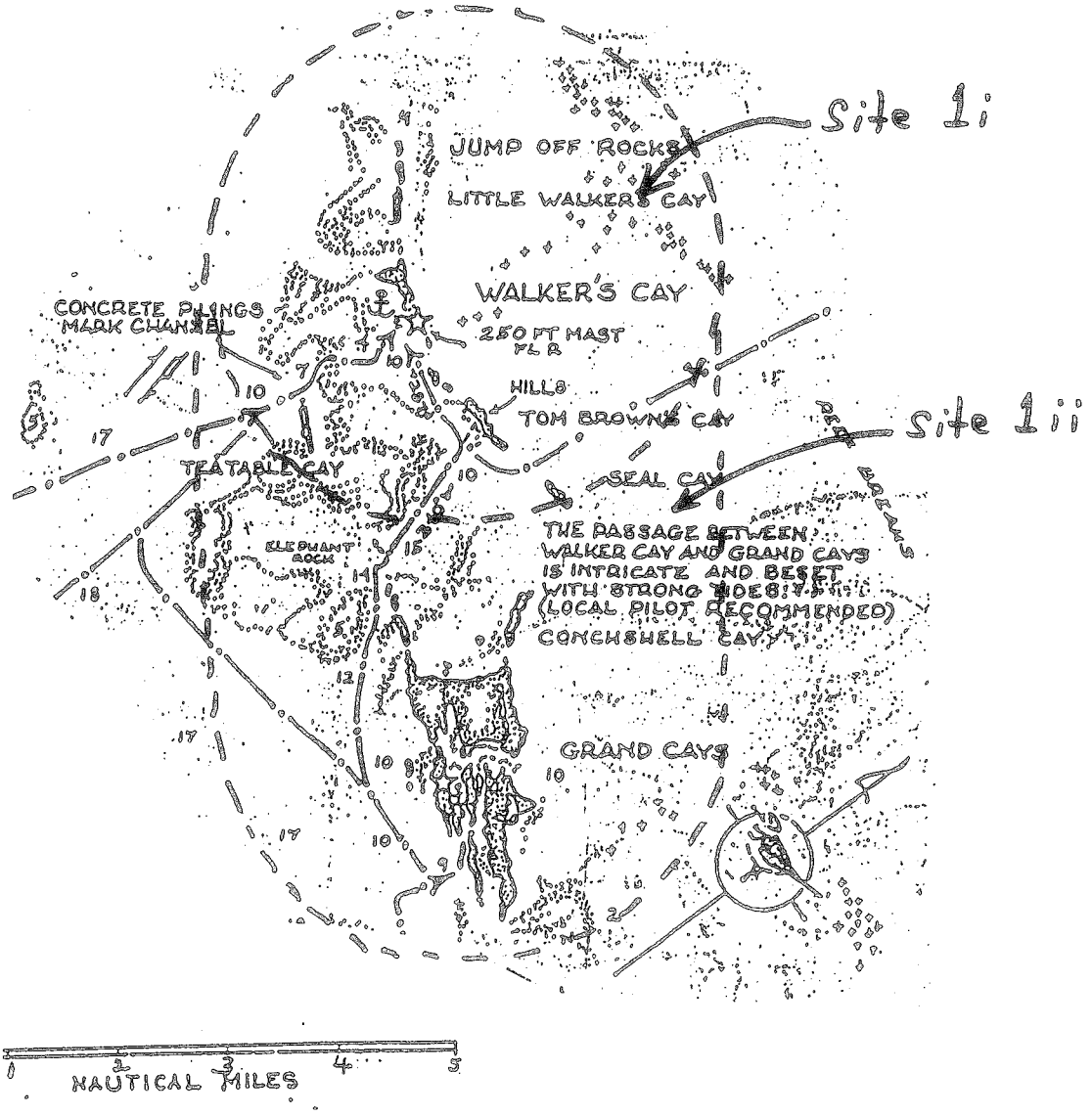
Site No.	Site	Region	Socioeconomic Criteria					Ecological Criteria				Totals		
			Fishing Impact	Community Participation	Community Benefits	Sociopolitical Uniqueness	Uniqueness Comments	Habitat Diversity	Regional Importance	Ecological Uniqueness	Uniqueness Comments	Socio-economic Average Score (1-3)	Ecological Average Score (1-3)	Total Priority Score (2-6)
1(i)	Abaco - Walkers Cay	N	2	3	3	3	already underway	2	1			2.75	1.50	4.25
1(ii)	Abaco - Walkers Cay and Grand Cay	N	1	2	3	3	already underway	3	1			2.25	2.00	4.25
2	Grand Bahama - Peterson Cay	N	3	2	1	3	existing land park	2	1			2.25	1.50	3.75
3	Abaco - Nun Jack Cay/Green Turtle Cay	N	2	2	3			3	1			2.33	2.00	4.33
4	Abaco - The Marls	N	3	1	1			1	1			1.67	1.00	2.67
5(i)	Abaco - Pelican Cays	N	2	3	3	3	existing land/sea park	2	1			2.75	1.50	4.25
5(ii)	Abaco - Pelican Cays to Little Harbour	N	2	2	3	3	existing land/sea park	3	2	3	24 marine blue holes in Little Harbor	2.50	2.67	5.17
6	North Bimini - East	C	3	3	1	3	research lab	2	1			2.50	1.50	4.00
7	Cat Cay	C	3	3	1			2	1			2.33	1.50	3.83
8(i)	Berry Islands - Frozen/Alder Cay	C	2	3	1			2	1			2.00	1.50	3.50
8(ii)	Berry Islands - Frozen Cay to Whale Cay	C	1	3	2			3	3			2.00	3.00	5.00
9a	Andros - Joulter Cays	C	1	2	2			3	3			1.67	3.00	4.67
9b	Andros - Central	C	2	3	3	3	already underway	3	2			2.75	2.50	5.25
10a(i)	New Providence - SW reef (as proposed)	C	3	3	2	3	already underway	2	1			2.75	1.50	4.25
10a(ii)	New Providence - SW reef (no take)	C	1	2	2			2	3	3	muttonfish spawning aggregation	1.67	2.67	4.33
10b	New Providence - Sea Garden	C	3	3	1			1	1			2.33	1.00	3.33
11	Eleuthera - Harbour Island	C	2	2	3			3	2			2.33	2.50	4.83
12	Eleuthera - East	C	3	2	1			2	2			2.00	2.00	4.00
13(i)	Eleuthera - Powell Point	C	2	2	2	3	Island School	2	3			2.25	2.50	4.75
13(ii)	Eleuthera - Powell Point/Schooner Cays	C	1	2	2	3	Island School	3	3			2.00	3.00	5.00
14	Exuma Cays Land and Sea Park	C	2	2	3	3	existing land/sea park	3	3			2.50	3.00	5.50
15	Green Cay	C	2	1	1			3	2			1.33	2.50	3.83
16	Little San Salvador	C	2	2	1			3	2			1.67	2.50	4.17
17	Cat Island - North	C	3	2	1			1	1			2.00	1.00	3.00
18	Cat Island - Old Bight	C	3	2	1			1	1			2.00	1.00	3.00
19	Exuma Cays - Lee Stocking Island	C	2	3	2	3	research center	3	3			2.50	3.00	5.50
20	Great Exuma - Jewfish Cays	C	3	2	1			2	2			2.00	2.00	4.00
21	Long Island - North	C	2	3	3			3	3	3	grouper spawning aggregation	2.67	3.00	5.67
22	Conception Island	C	3	1	1	3	existing land park	3	3	3	barrier reef and coral pinnacles	2.00	3.00	5.00
23(i)	San Salvador - West	C	3	2	2			2	2			2.33	2.00	4.33
23(ii)	San Salvador - Northeast	C	3	3	2	3	field station	3	2			2.75	2.50	5.25
24	Rum Cay	C	3	2	2			3	2			2.33	2.50	4.83
25	Long Island - Sandy Cay	C	2	2	1			2	2			1.67	2.00	3.67
26	Crooked Island - Northwest	S	2	2	2			3	3	3	grouper spawning aggregation	2.00	3.00	5.00
27	Acklins - North	S	3	1	2			3	3			2.00	3.00	5.00
28	Mayaguana - Pirates' Well	S	3	2	2			3	2			2.33	2.50	4.83
29	Hogsty Reef	S	3	1	1			2	3	3	only atoll in Bahamas	1.67	2.67	4.33
30	Great Inagua - North	S	3	2	2	3	existing land park	3	3			2.50	3.00	5.50
31	Grand Bahama - Sweetings Cay	N	1	2	2			3	2			1.67	2.50	4.17
32	Grand Bahama - North	N	3	1	1	3	existing land park	1	1	3	unique cave system	2.00	1.67	3.67
33	Cay Sal Bank	W	3	1	1			2	2	3	large area/major turtle nesting ground	1.67	2.33	4.00
34	Cat Island - East	C	3	2	2			3	2	3	abundant *Acropora* corals	2.33	2.67	5.00
35	Andros - South	C	2	2	2			3	3	3	grouper spawning aggregation	2.00	3.00	5.00
36	Ragged Island Chain - Central	S	3	1	1			3	3			1.67	3.00	4.67
37	Little Inagua	S	3	1	1	3	existing land park	2	3			2.00	2.50	4.50

Map of proposed marine reserve sites



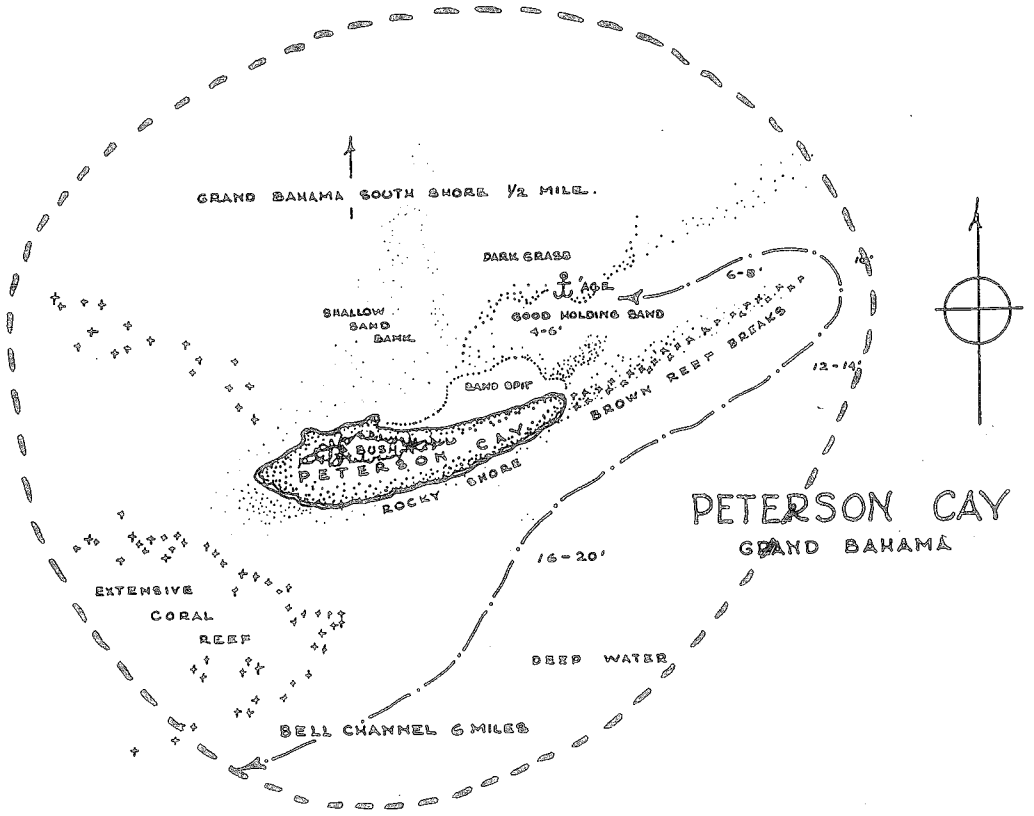
1(i): Abaco - Walkers Cay, 1(ii): Abaco - Walkers Cay and Grand Cay

The area around Walker's Cay includes extensive healthy reef and some seagrass areas. The reef is heavily dived by a resort on the cay. Walker's Cay is developed and there is no remaining mangrove. Expanding the park to include Grand Cay would include mangrove habitat, but would also encompass traditional fishing grounds.



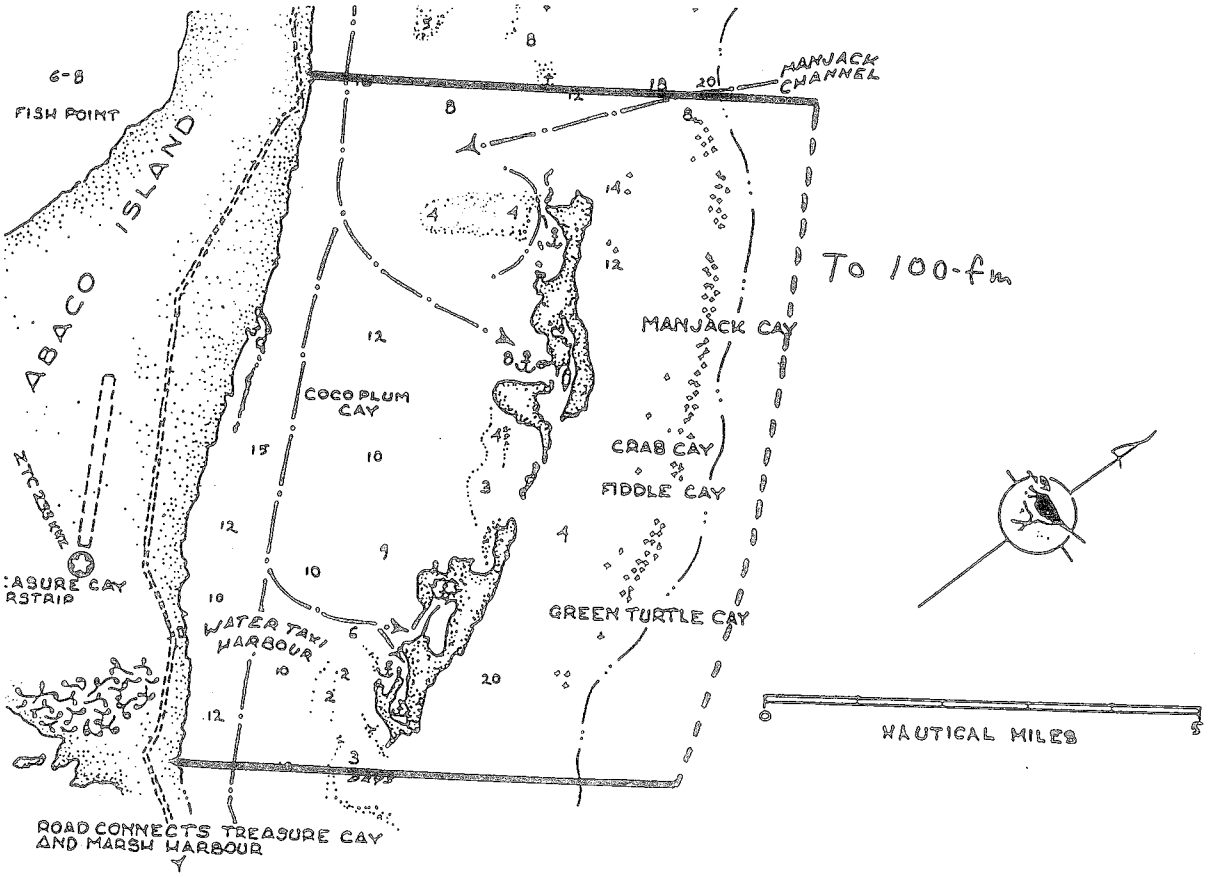
2: Grand Bahama - Peterson Cay

Peterson's Cay is a 1.5 acre cay about 1.5 miles off Grand Bahamas southern shore, and is one of the few cays off southern Grand Bahama. The cay is currently a National Park and recreational area. It is proposed to extend the Park into the surrounding marine area, however it would still be relatively small.



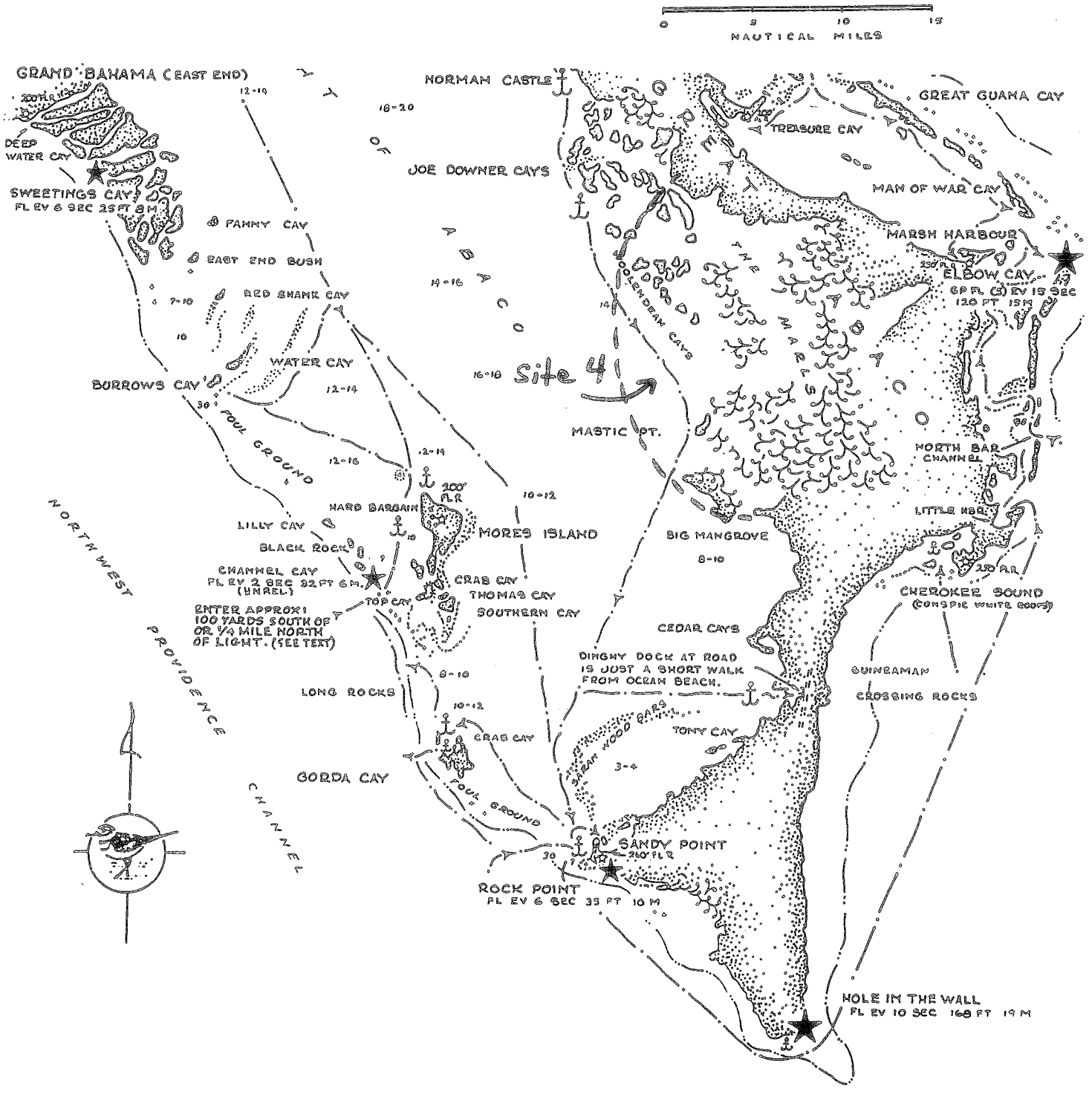
3: Abaco - Nun Jack Cay (Man Jack Cay) to Green Turtle Cay

These cays are situated on the Abaco barrier reef, and the proposed park area includes healthy reef, seagrass and mangrove areas. There are fishing communities on the cays and the proposed area is fished by local residents and visiting yachts.



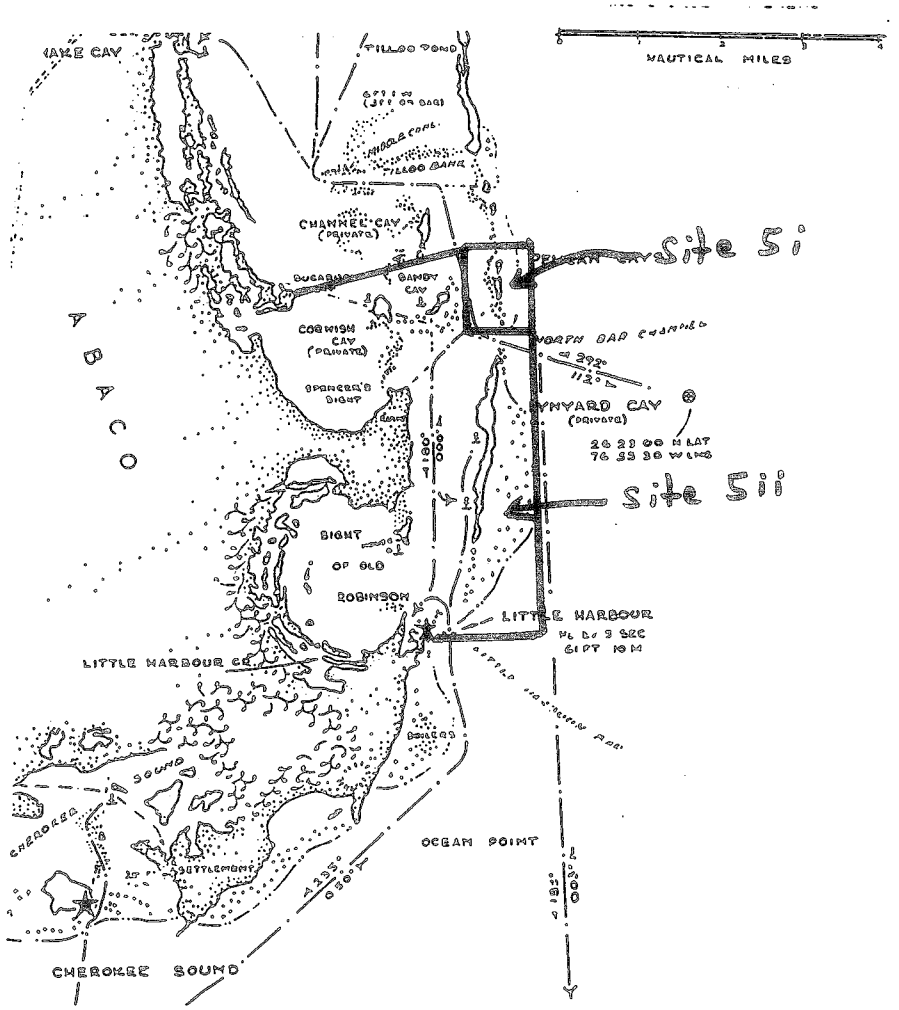
4: Abaco - The Marls

The Marls is a large site in the apex of the Great Abaco Bight, characterized by shallow water, mud and mangroves. While this site is large and may provide nursery for crawfish and certain fish species, habitat diversity is low. Human interference appeared to be low, given the difficulties of access by both land and water. No settlements are nearby. The site could be important for waterfowl.



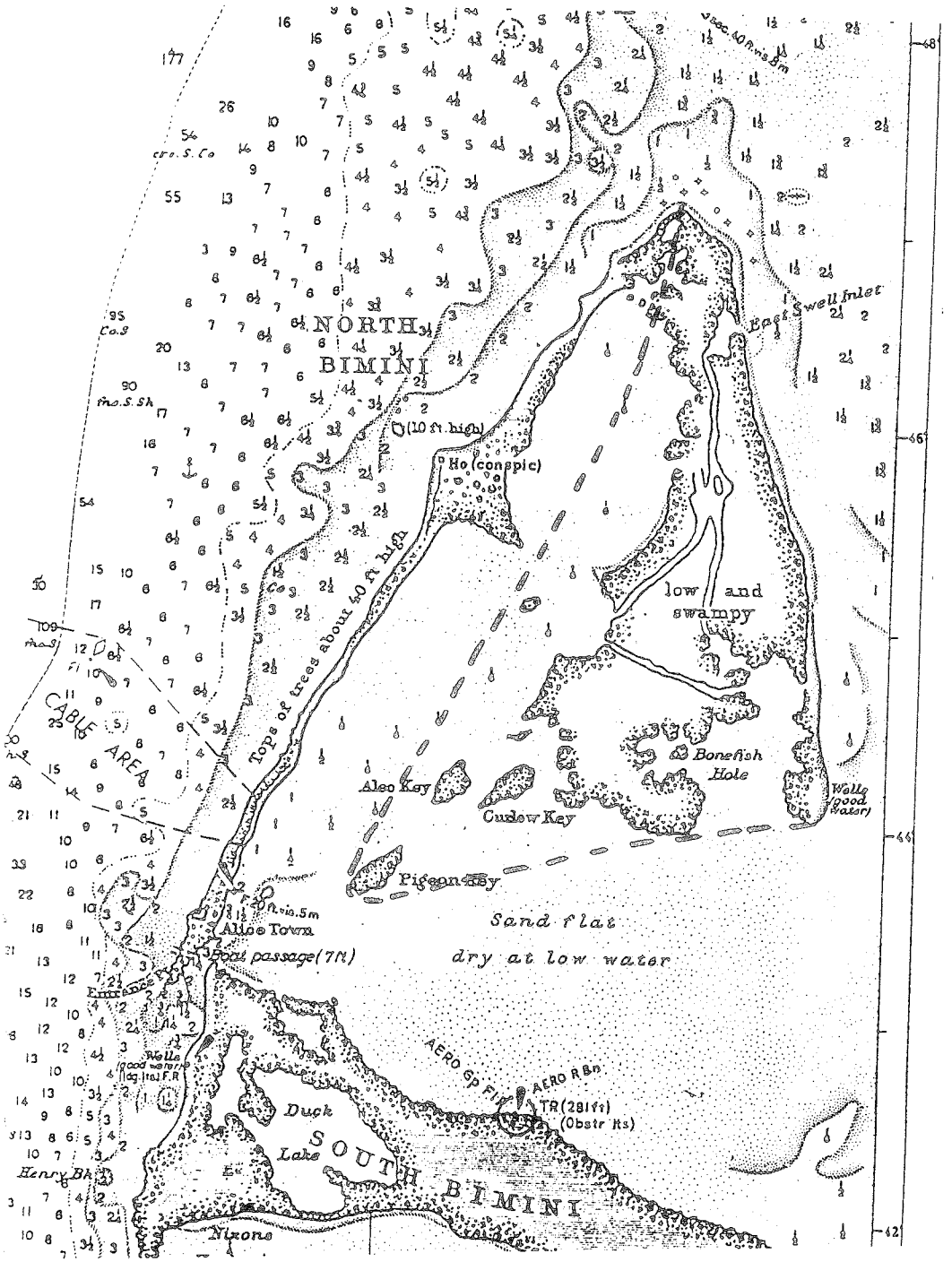
5(i): Abaco - Pelican Cays, 5(ii): Abaco - Pelican Cays to Little Harbor

The Pelican Cays are a 1-mile long series of small privately owned cays and rocky ledges along the eastern shelf of Great Abaco. The existing Pelican Cays Land and Sea Park is a 2,100 acre area that includes limited coral reef areas. Given its small size, the panel considered an expanded area (site 5ii), which included all of the shelf from North Pelican Cay to Little Harbor on the mainland of Great Abaco. This provides an extensive coral reef area off Lynyard Cay, large seagrass beds and mangroves west of the cays, and the inner part of Little Harbor. In the extreme western section of Little Harbor, there are 24 marine blue holes with unusual coral formations and reef fish communities.



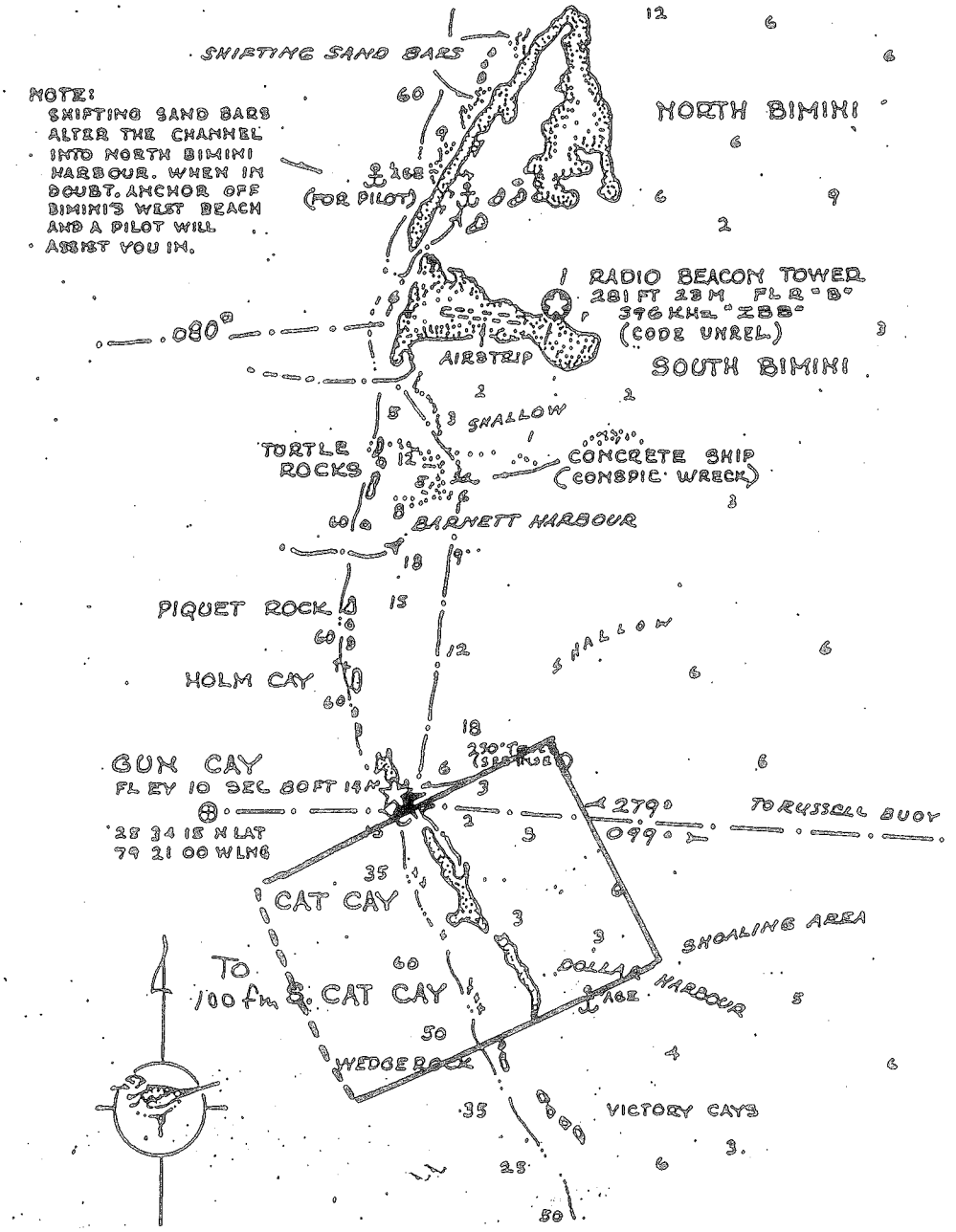
6: North Bimini - East

The eastern half of Bimini Sound and adjacent waters contain mangrove and seagrass habitats. The mangrove system is an important nursery habitat for lemon sharks (researched by the Bimini Biological Field Station) as well as commercially important species. Because it is one of the few mangrove systems on the western edge of the Great Bahama Banks, it may be an important nursery area for many species on a regional scale. Catch-and-release bonefishing is important within the proposed reserve area.

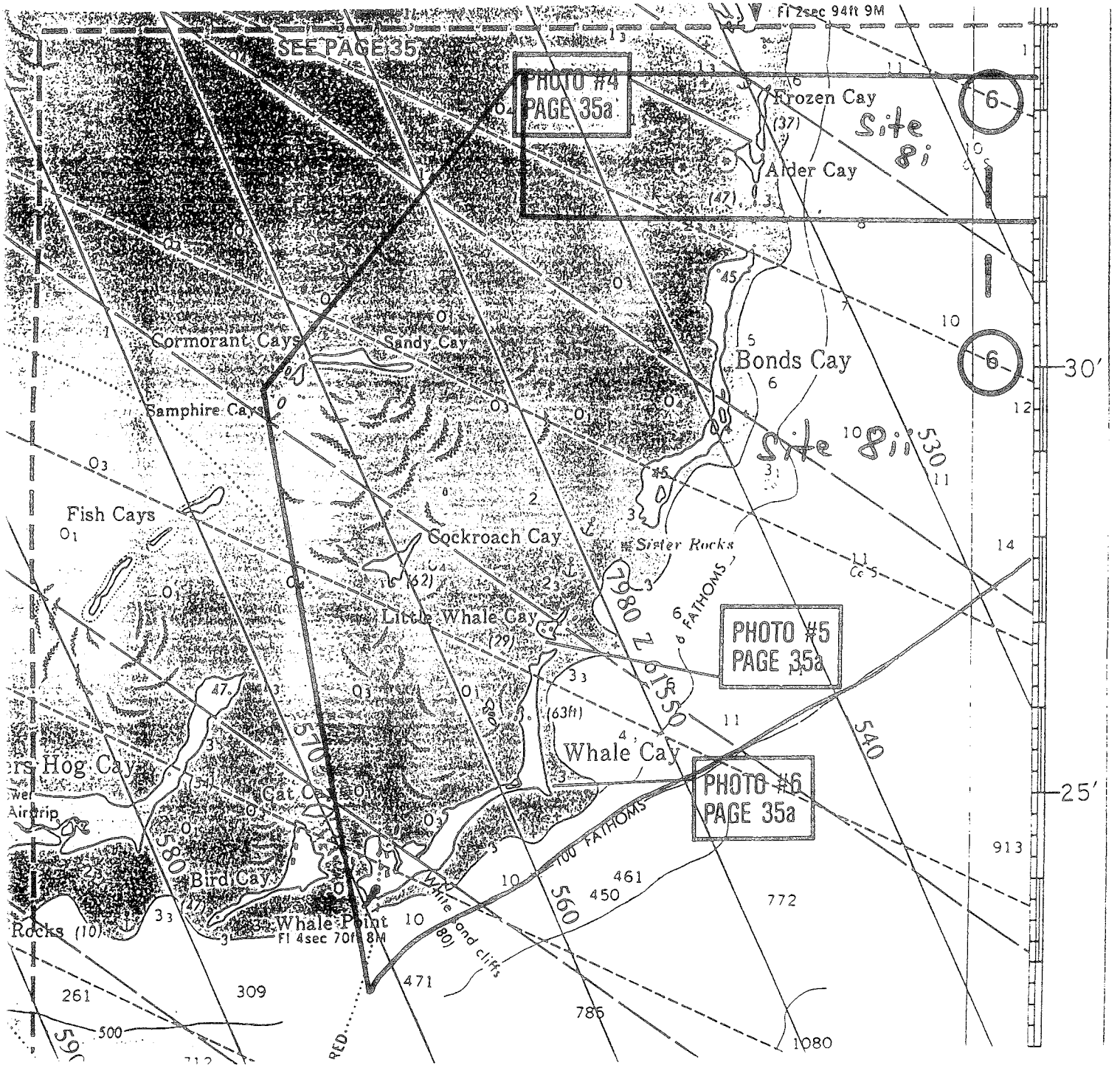


7: Cat Cay

Cat Cay and South Cat Cay are similar to Bimini geographically, but do not possess the extensive mangrove system of Bimini. A reserve in this area would protect coral reef and some bank habitats, primarily bare substrate and some seagrass. Because of its location and small size, it is not likely to have large regional ecological importance. Because Cat Cay is a private club, there may be support for creating a reserve around the island.

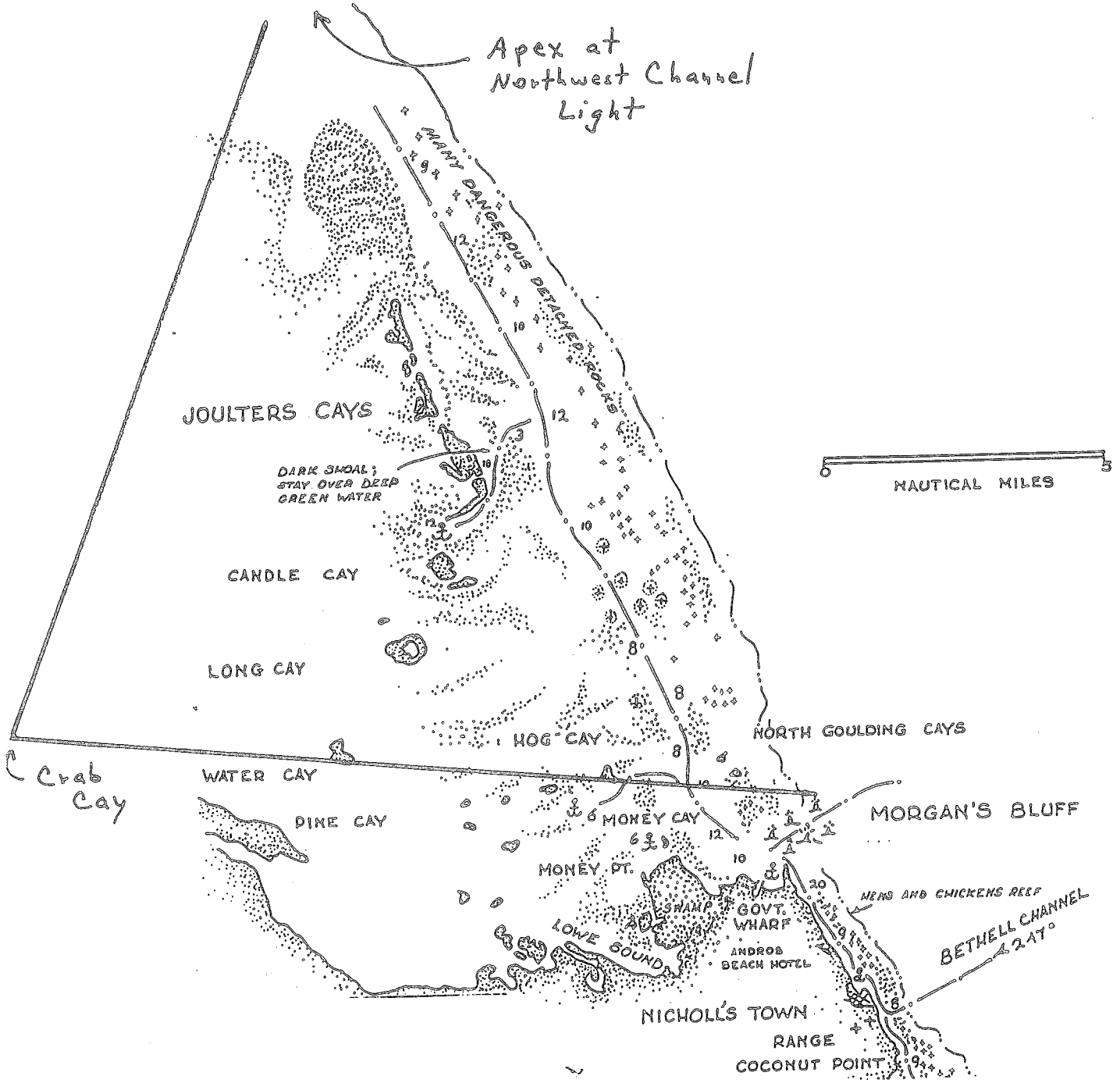


8(i): Berry Islands - Frozen/Alder Cays, 8(ii): Berry Islands - Frozen to Whale Cay
Frozen and Alder Cay are two small, privately owned cays in the eastern Berry Islands. The habitat around Frozen and Alder Cays includes seagrass meadows and some coral reef formations on the narrow island shelf, however the proposed reserve would be too small to be valuable for fisheries purposes. The owners of these private islands have expressed interest in supporting a marine reserve, however it is reported that they may be for sale. Expanding the proposed site to include the area between Frozen and Whale Cay would protect extensive coral reefs offshore from Whale Cay and Bond Cay, as well as extensive seagrass beds known to support large numbers of conch. The increase in size would increase spawner biomass and provide greater benefit to the entire region.



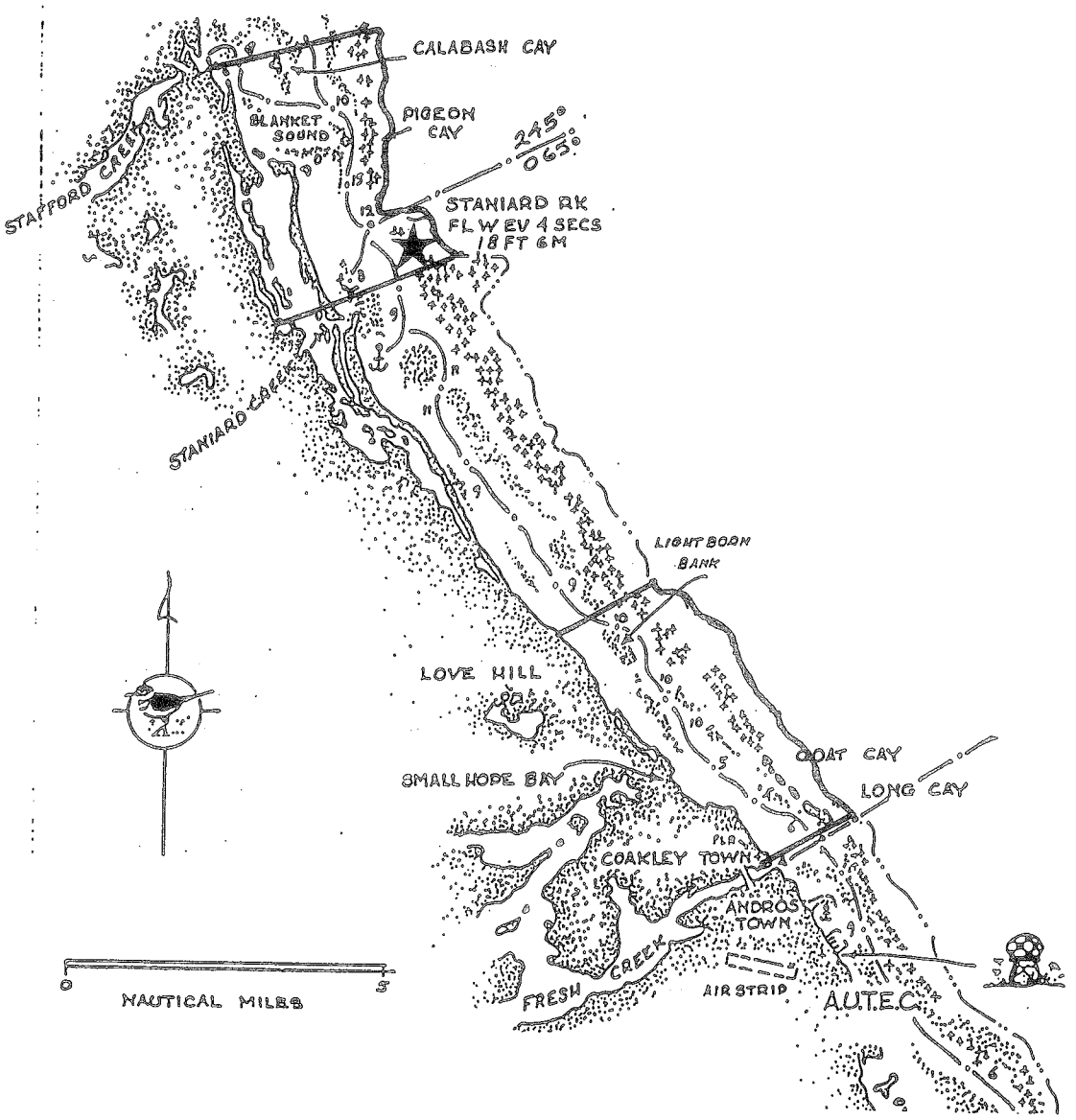
9a: Andros - Joulter Cays

This site includes extensive coral reefs on the eastern edge of the shelf, particularly in the south. Large expanses of seagrass are found on the shallow bank, interspersed with sand banks and tidal channels. Mangroves fringe the southern part on the main island of Andros. This site appears to have excellent habitat for juvenile and adult stages of conch, lobster and reef fishes.



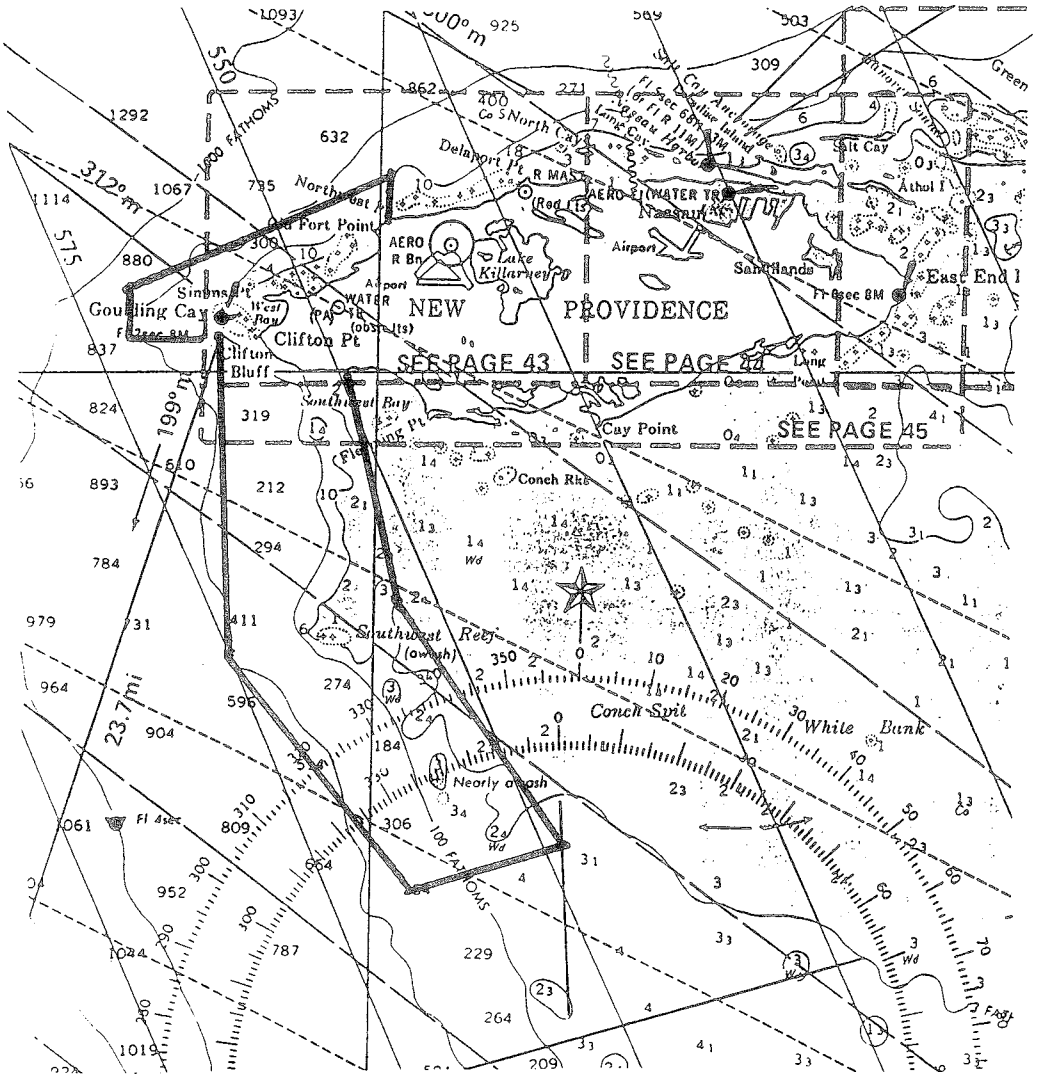
9b: Andros - Central

The Central Andros Conservancy and Trust / Bahamas National Trust has proposed the designation of several terrestrial and marine areas of Central Andros to be included in a protected area zoned for several purposes. The zoning plans calls for two no-take marine reserves that extend from the high tide line to the 100 fathom line. These areas, totaling about 16-18 square miles extend from shore to the shelf edge and contain a diversity of habitats (mangrove, seagrass, patch reefs, barrier reef). Because these areas are located close to a community, and allow non-consumptive uses, they are likely to provide benefits related to diving and ecotourism, industries which are growing rapidly in Central Andros.



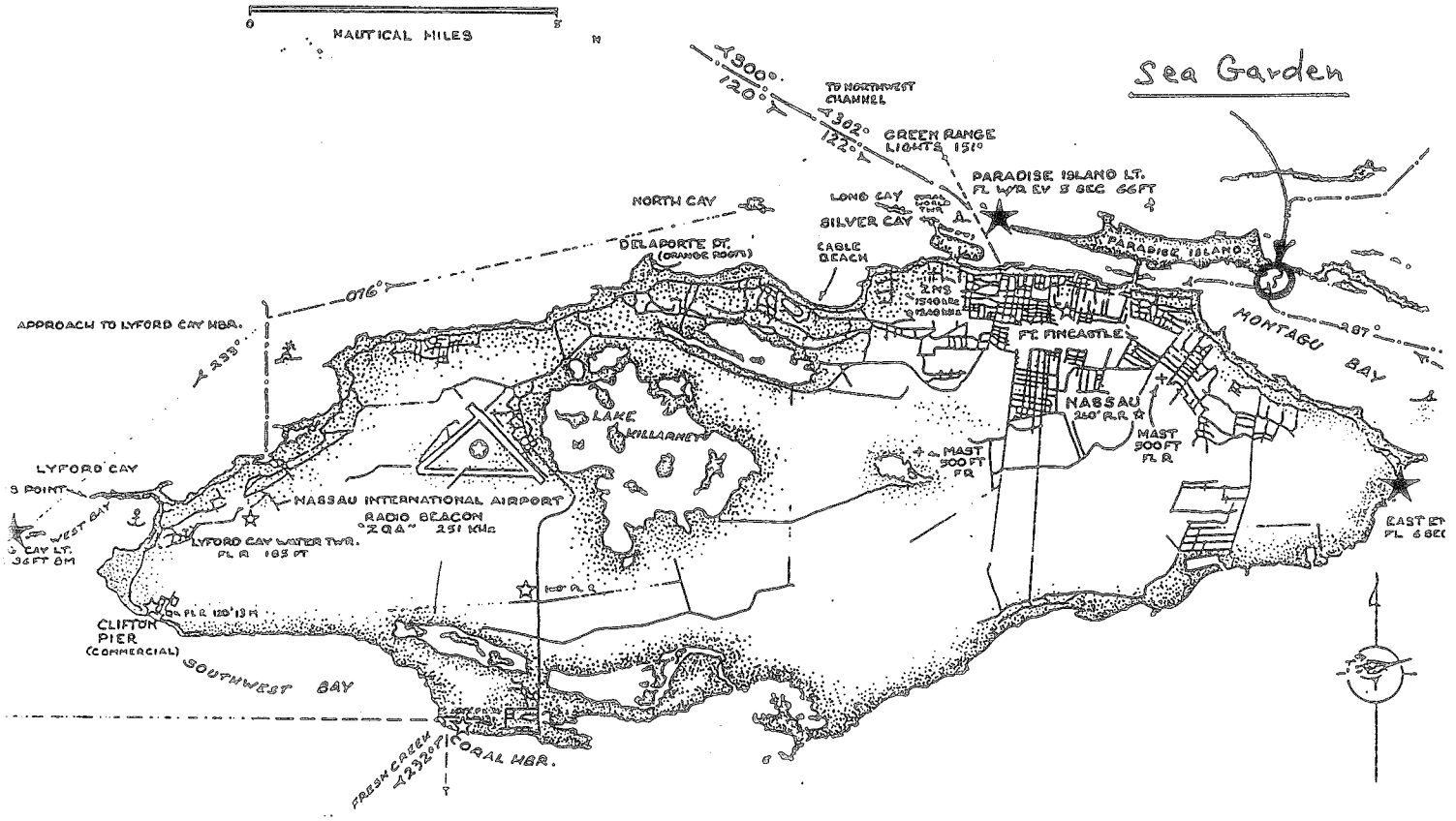
10a(i): New Providence - Southwest Reef (as proposed), 10a(ii) New Providence - Southwest Reef (no-take)

This area, proposed as a reserve by Ocean Watch and the Bahamas National Trust, runs along the drop-off, and contains coral reefs that are healthy and heavily dived, including an area used to feed sharks. The area also includes traditional fishing grounds, particularly during the muttonfish spawning season. As proposed, fishing would be limited to certain gear types in most of the area, with some areas designated as no-take reserves. Fishing would continue to be permitted on the muttonfish spawning aggregation. Because few small areas are being proposed as no-take reserves, there will be little negative impact to fishing in the area; however, the ecological benefits provided by the reserve are likely to be minimal. Designating the entire proposed area as no-take would provide increased ecological benefits, particularly if the muttonfish spawning aggregation was included, however it would also be problematic socially.



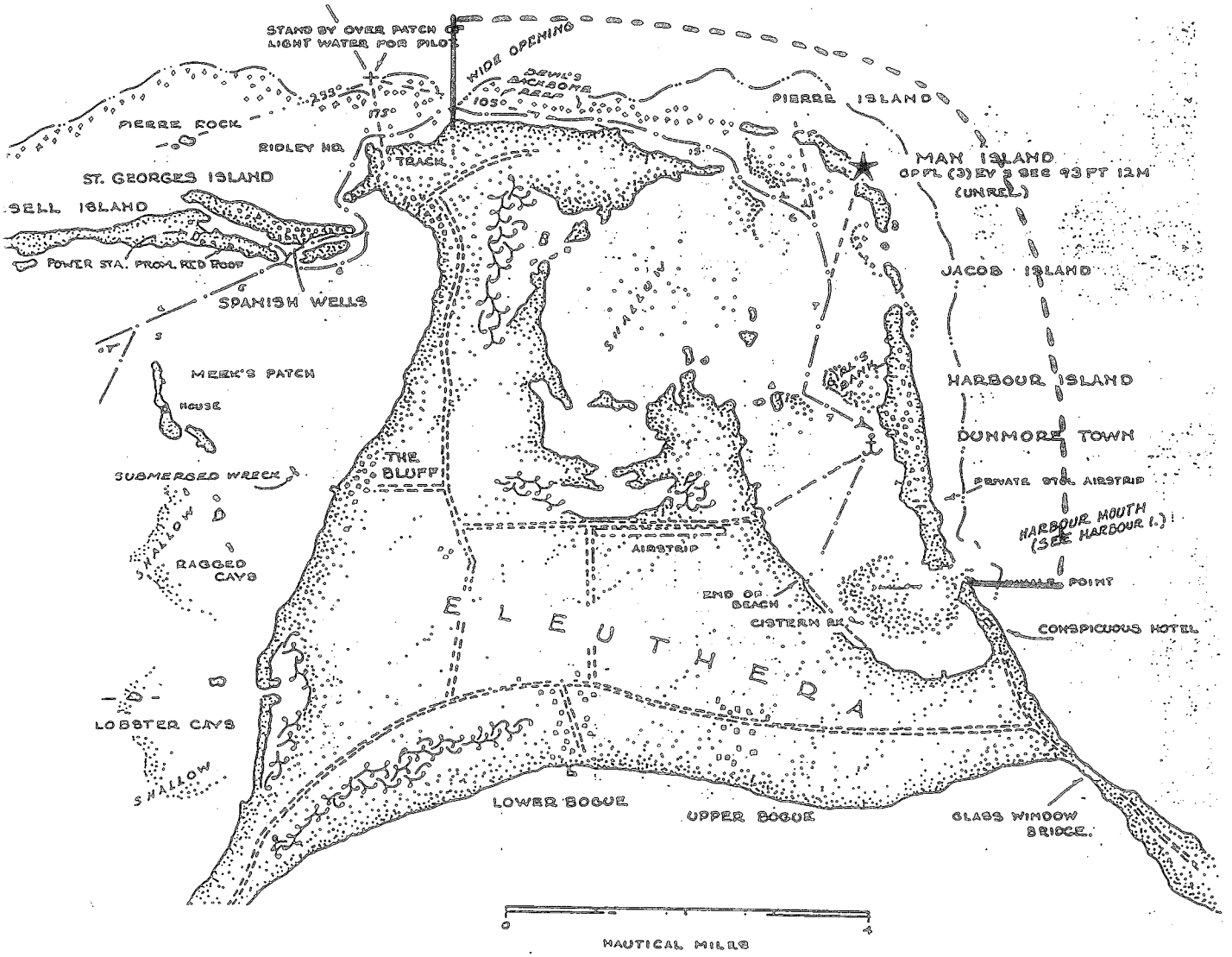
10b: New Providence - Sea Garden

The "Sea Garden" is an area east of Nassau where glass bottom boats take tourists to observe fish feeding. There are apparently many fish in this area despite the absence of high quality habitats, probably because fish are fed regularly. Given that the habitat is degraded and that little or no fishing takes place in this area currently, it is likely that the ecological benefits of a reserve in this area would be minimal.



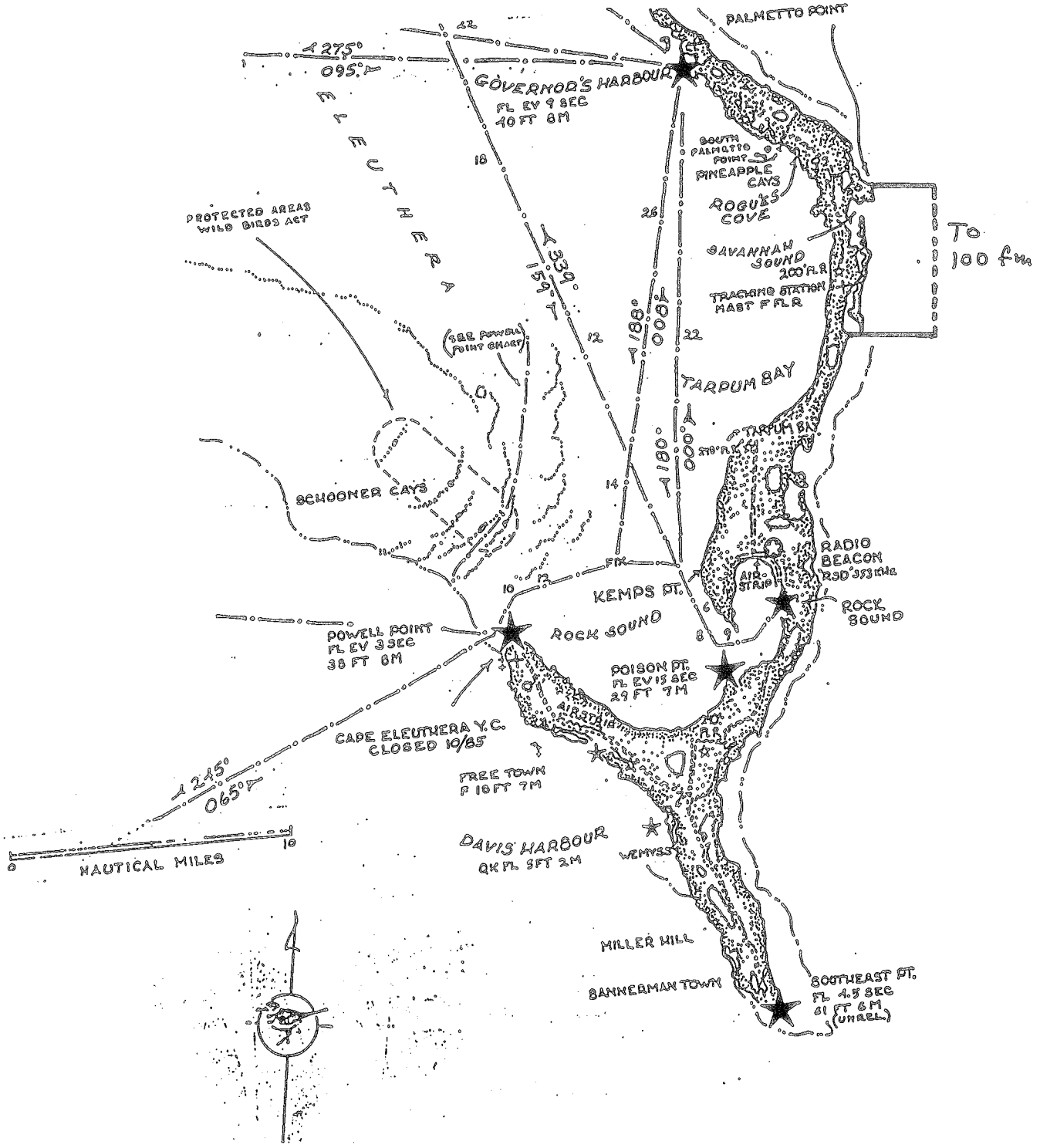
11: Eleuthera - Harbour Island

Harbour Island is separated from the mainland by a shallow lagoon area with large amounts of seagrass and small mangrove covered cays. The reef offshore from Harbour Island is healthy and used by several dive centers in the area. There is a small local fishery in and around Harbour Island, as well as numerous visiting recreational fishermen, however the island's main industry is tourism and it is likely that this industry would benefit from the presence of a reserve.

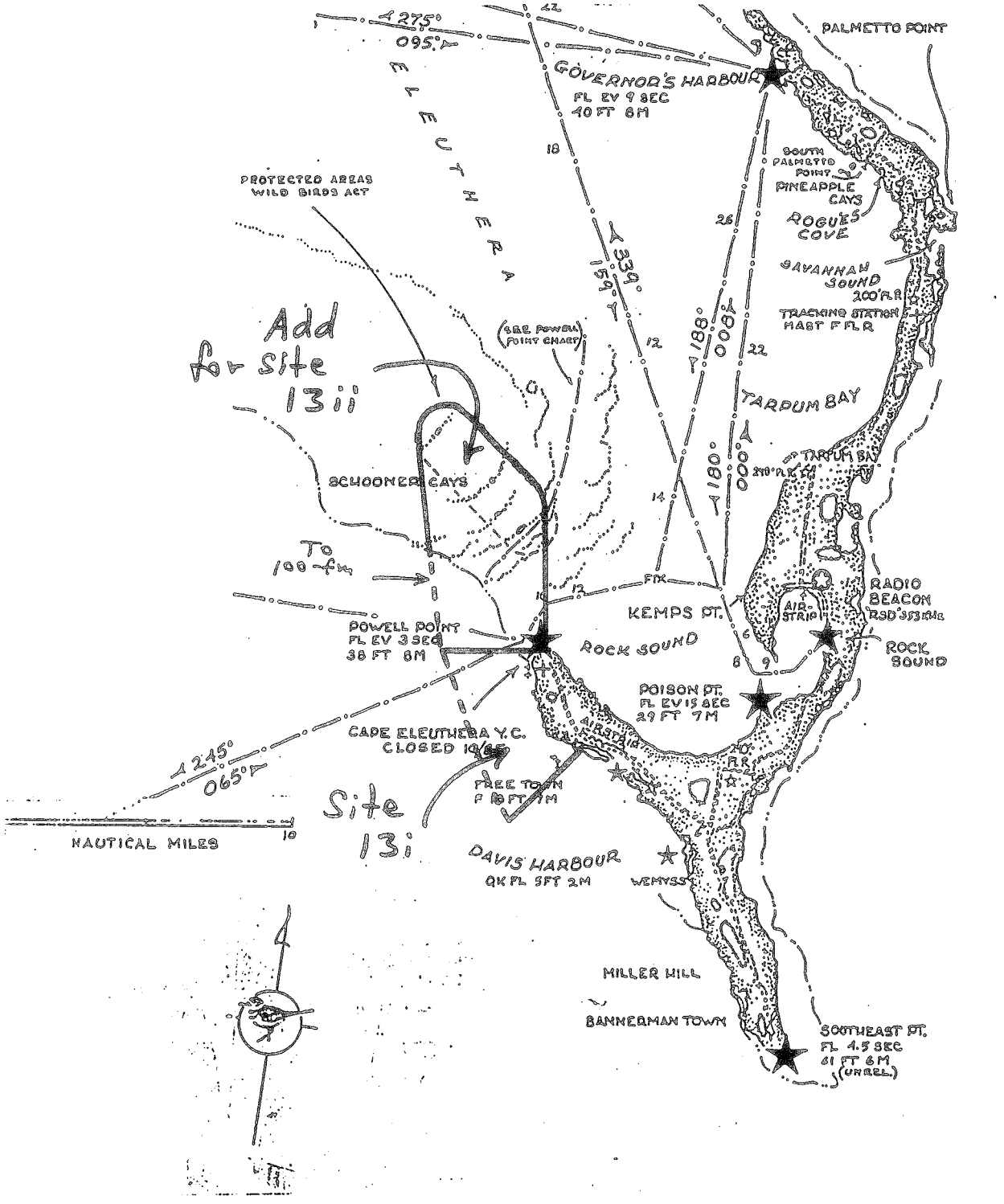


12: Eleuthera - East

The Atlantic side of Eleuthera has a relatively narrow shelf edge fringed with coral reefs. There are unconfirmed reports from locals that the proposed reserve area would include reefs with the soft coral *Pseudopterogorgia* spp. Species within this genus are being examined by chemical ecologists for possible use in pharmaceuticals.

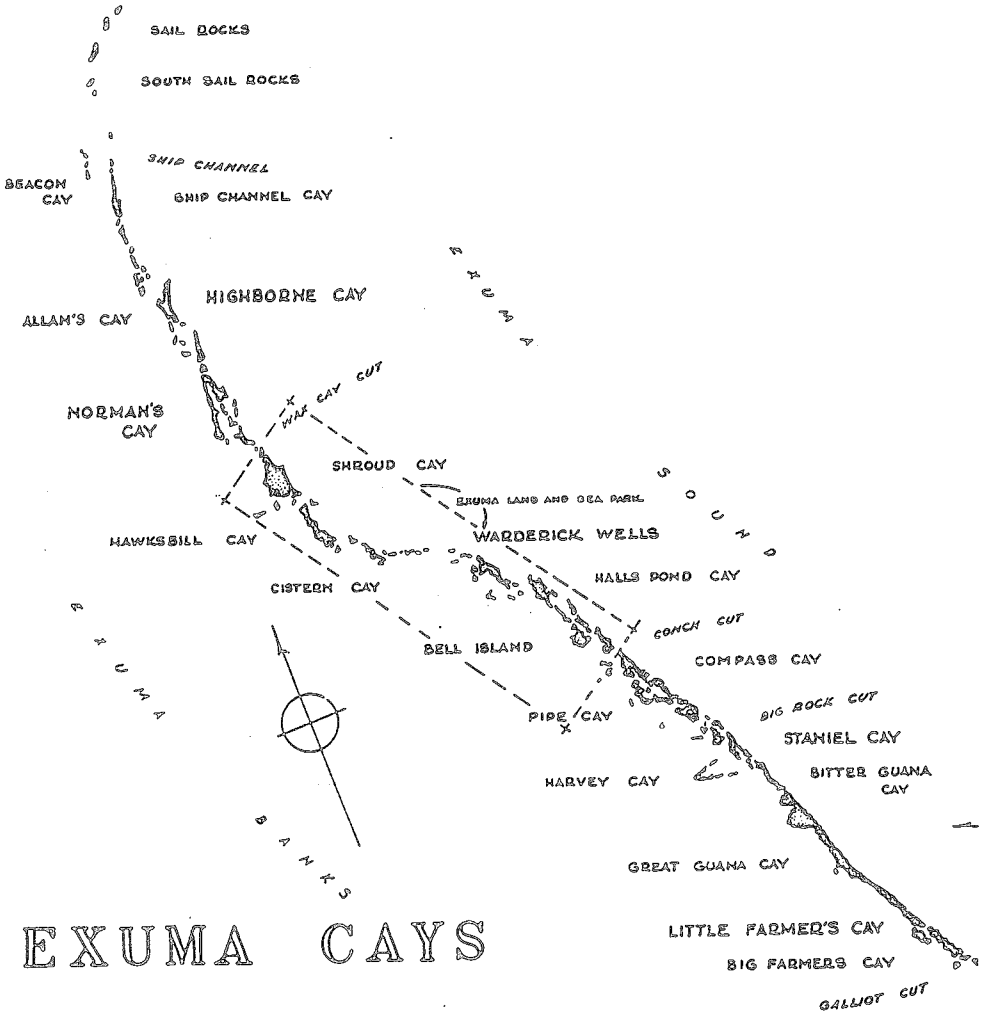


13(i): Eleuthera - Powell Point, 13(ii): Eleuthera - Powell Point/Schooner Cays
The initial proposal for this site was east and north of Powell Point. This includes some seagrass meadows and a narrow area of reef tract at the shelf edge; however, much of the area is sandy bottom with little habitat. On the recommendation of the Department of Fisheries, site 13(i) was moved to the west side of Powell Point, which includes a narrow shelf with a band of seagrass and well-developed reef. With the boundaries expanded to include the Schooner Cays, the area includes large areas of seagrass and deeper hard-bottom habitat which are known to provide important nursery grounds for crawfish and conch. The Schooner Cays are fished heavily for conch.



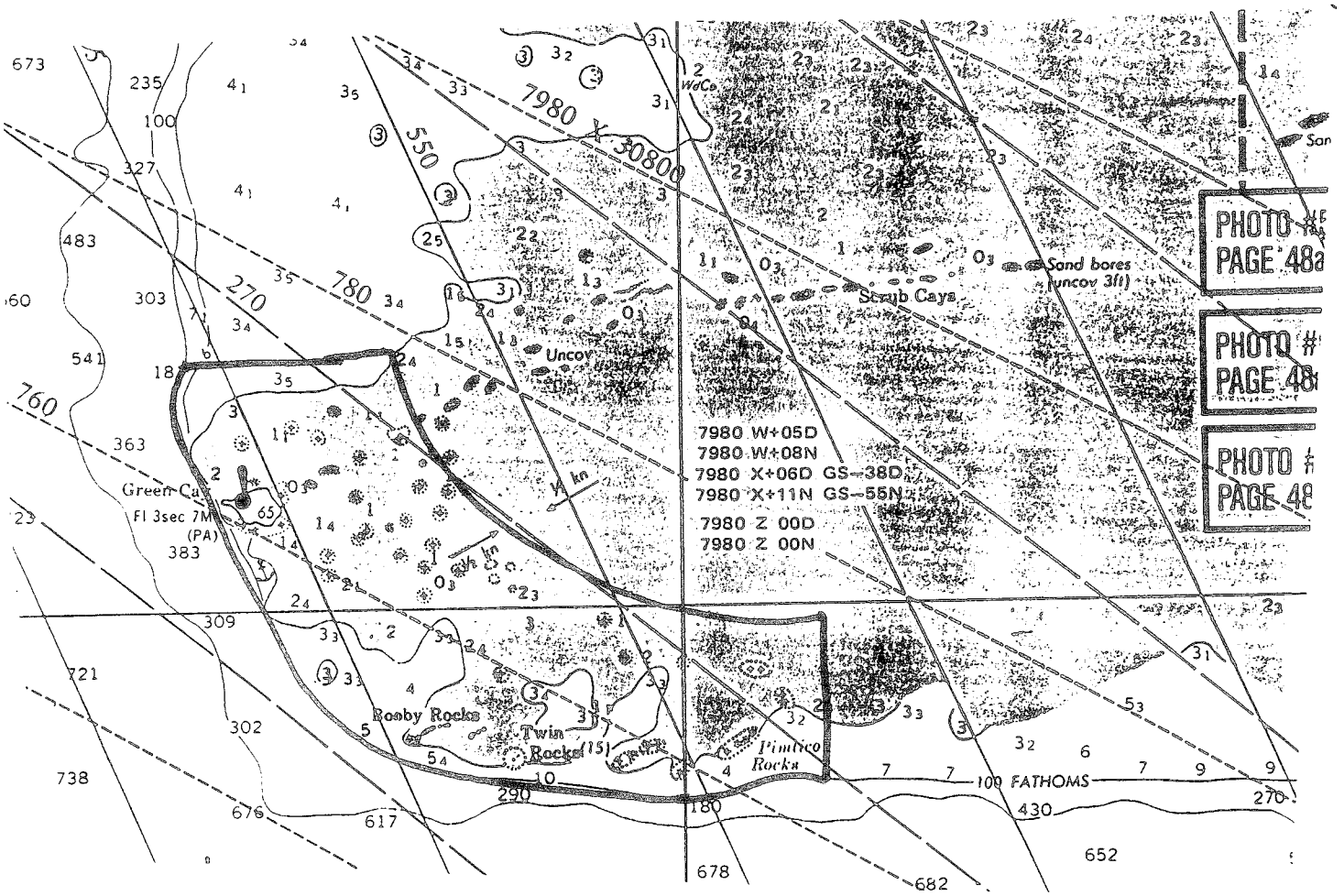
14: Exuma Cays Land and Sea Park

As one of the largest no-take marine reserves in the world, the Exuma Cays Land and Sea Park has been shown to be effective at conserving biomass of comercially important species, and may support fisheries outside of its boundaries. These benefits may be attributed to the fact that the park is entirely no-take, a large area containing a wide variety of essential habitats, and located in an area where currents may export larvae to other suitable areas. It is included in this report for purposes of comparison.



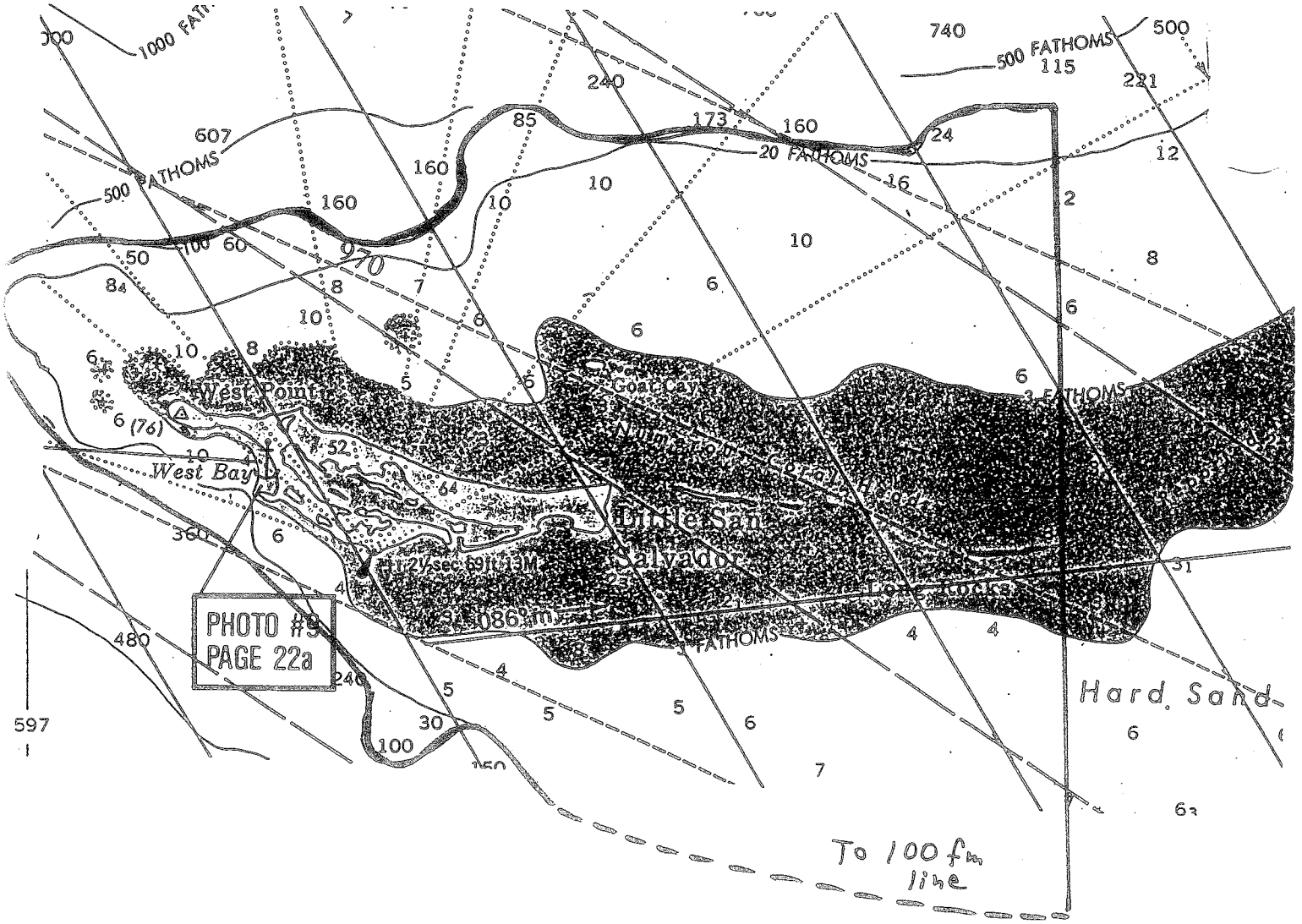
15: Green Cay

Green Cay is an isolated island on the eastern side of the Tongue of the Ocean with no permanent dwellings; however, it provides an anchorage and a fishing ground. Coral reefs are found along the southern and eastern shoreline and around the rocks and ledges extending eastwards from the cay over the Great Bahama Bank. There are areas of mangrove and seagrass beds although the seagrass beds are relatively sparse.



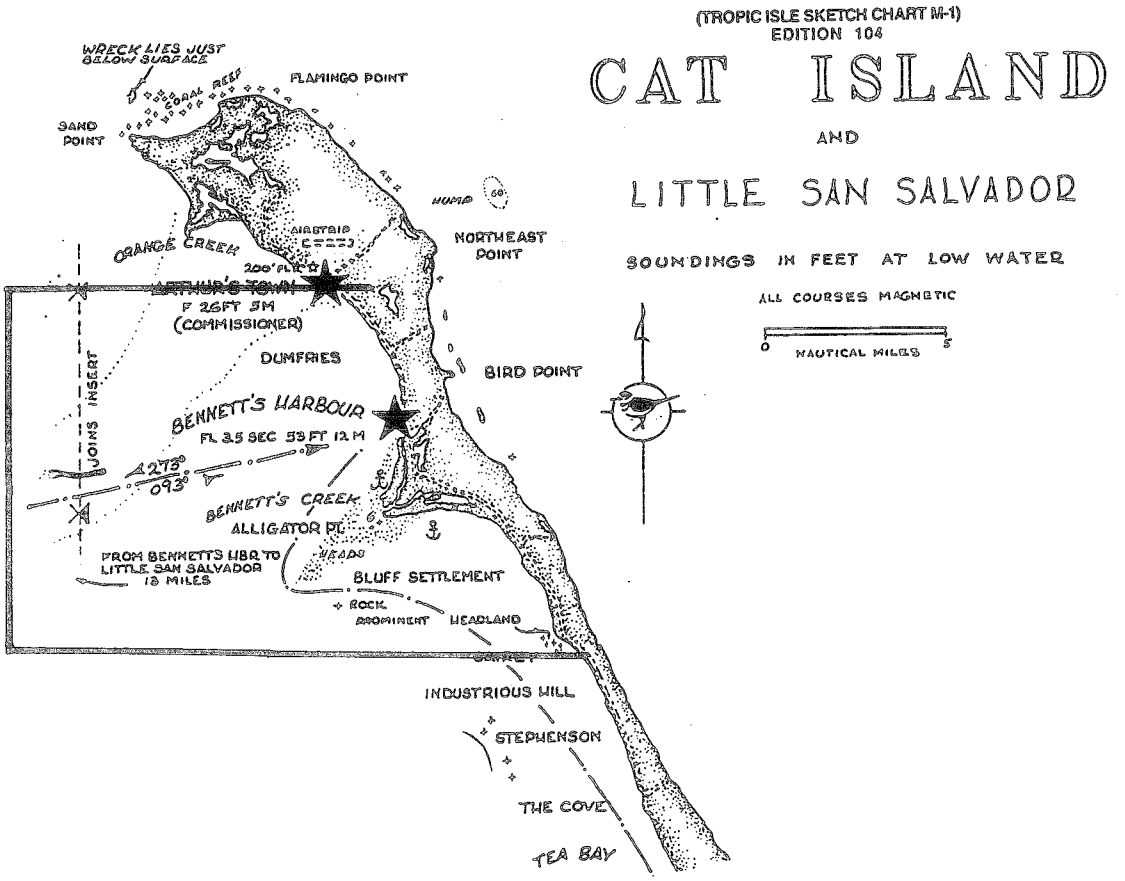
16: Little San Salvador

The area around Little San Salvador contains coral reef areas along the windward shore and to the east towards Cat Island (around Long Rocks). The central lagoon provides a variety of nursery habitats including seagrass and mangroves. Although there is no permanent settlement on the island, it is a stopping point for cruise ships and appears to be occupied at most times. This may facilitate reserve acceptance and enforcement.



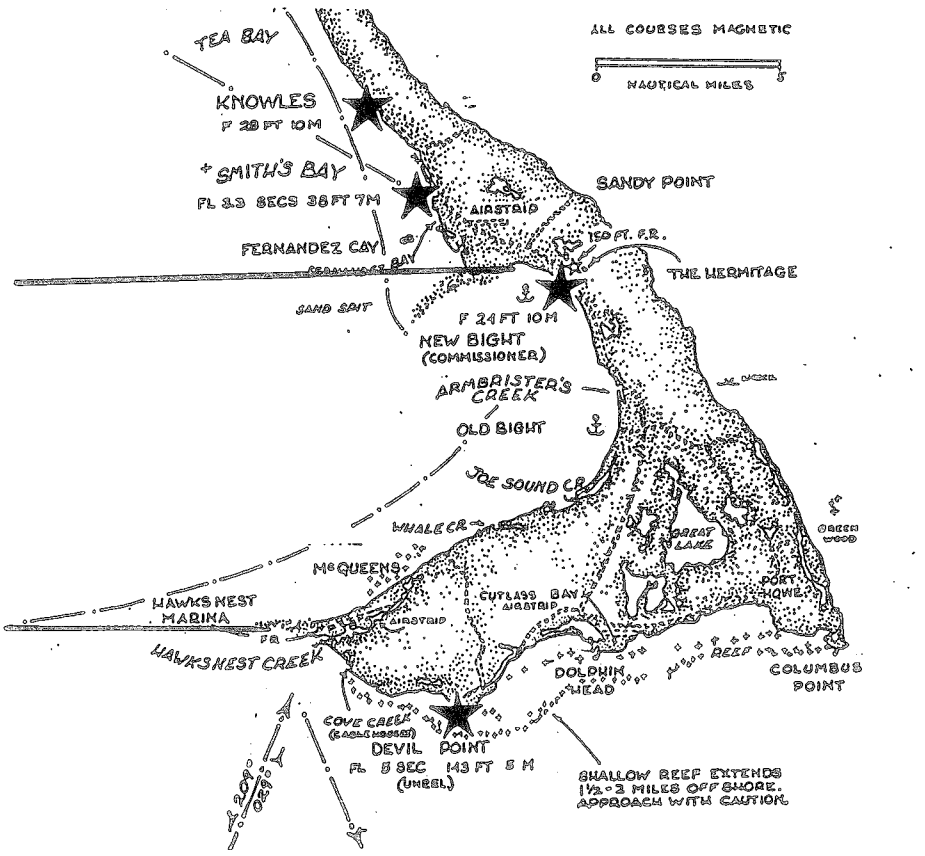
17: Cat Island - North

The northwest shore of Cat Island has limited patch-reef development, some seagrass, and mangroves; however, this site has relatively low habitat complexity. Habitats become increasingly diverse with proximity to Little San Salvador.



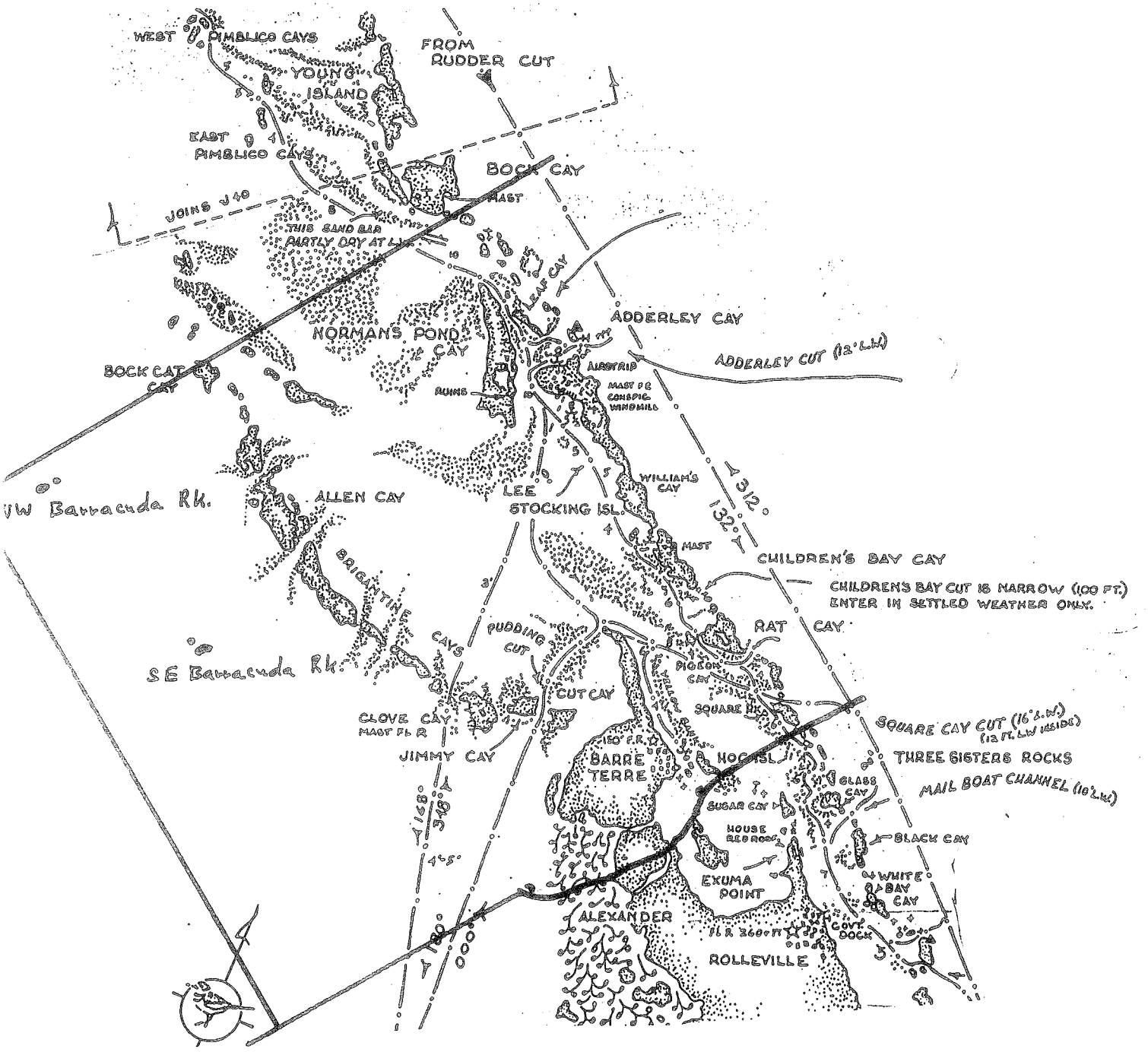
18: Cat Island - Old Bight

The wide shelf on the south of Cat island contains several small patch reefs, and some mangrove creek/macroalgal nursery systems, however the majority of the substrate appears to be bare sand. Studies of lobster and conch in Exuma Sound suggest that this area may receive high levels of larval settlement, but it is not a productive area for either species.



19: Exuma Cays - Lee Stocking Island

The area around Lee Stocking Island (including other islands in the southern Exumas and the Brigantines) contain a diversity of habitats including mangroves, seagrass beds, patch reefs, and offshore reefs. All these habitats have been well studied by scientists at the Caribbean Marine Research Center on Lee Stocking Island. The presence of a no-take control area for these scientists would be extremely valuable.



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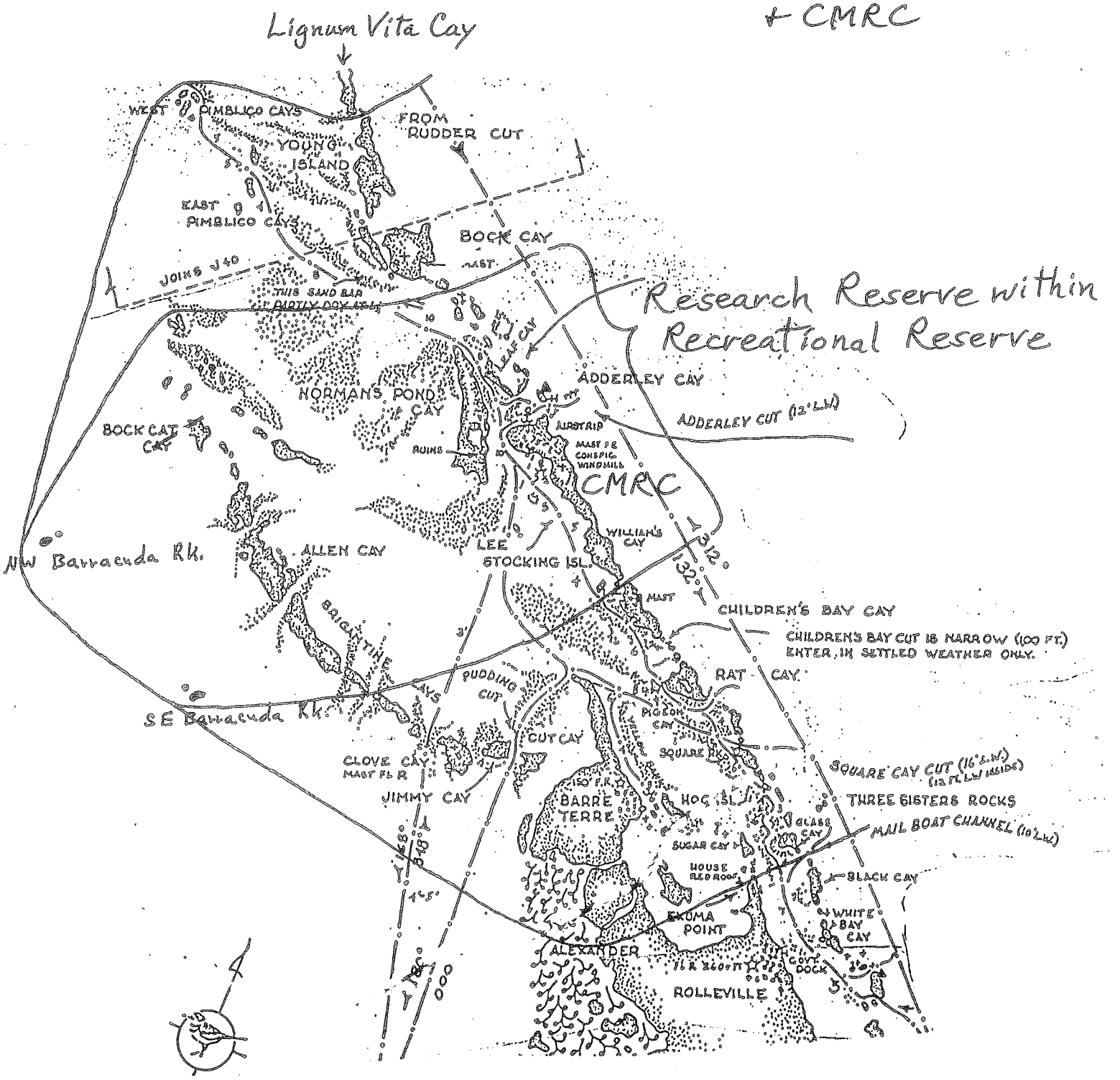
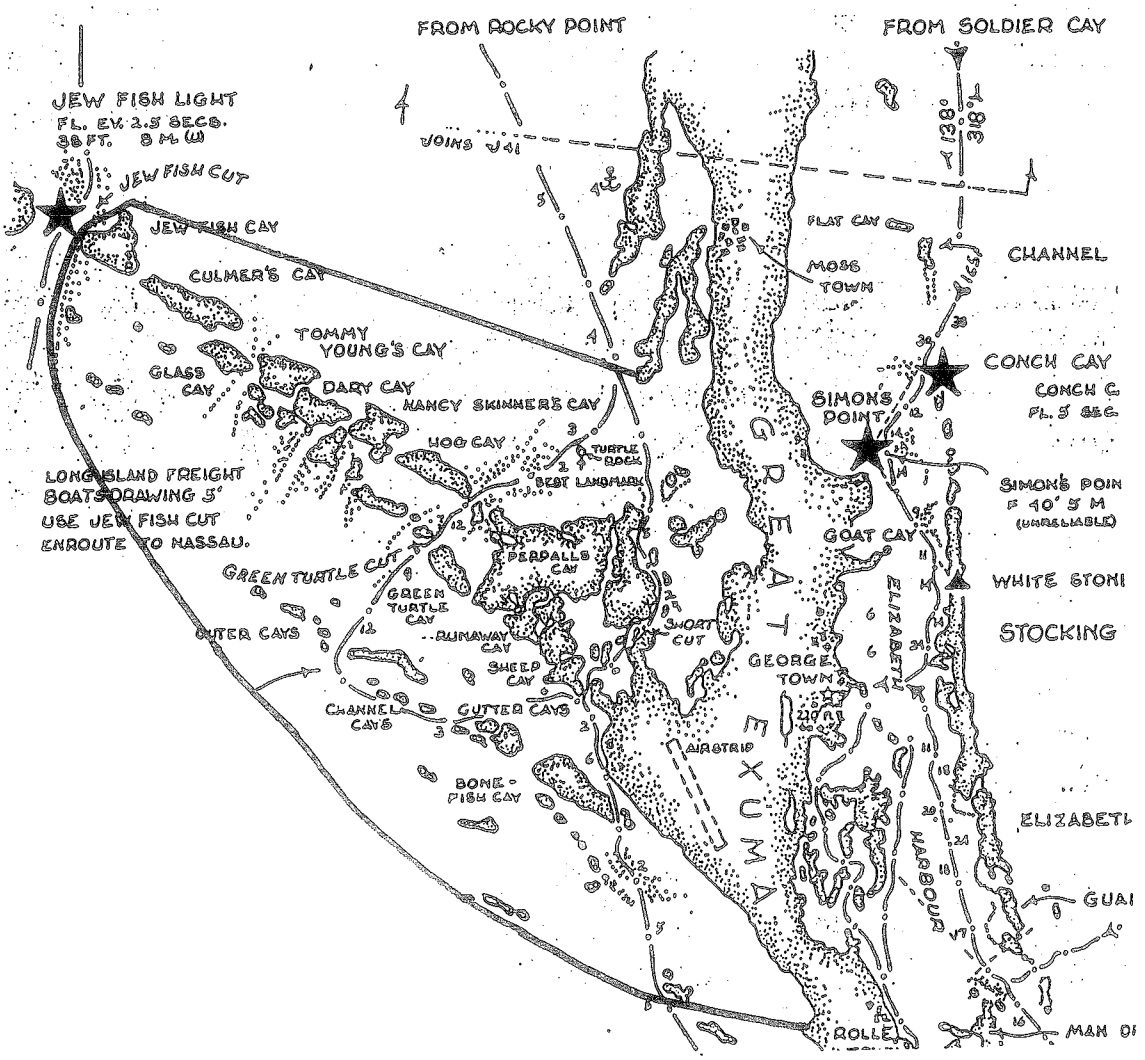


20: Great Exuma - Jewfish Cay

The chain of cays on the bank side of Great Exuma contain mangrove areas surrounded primarily by bonefish flats. There is apparently little fishing in this area at the present except for catch and release bonefishing. Although the local community is supportive of a reserve, there is no nearby settlement to help enforce it.



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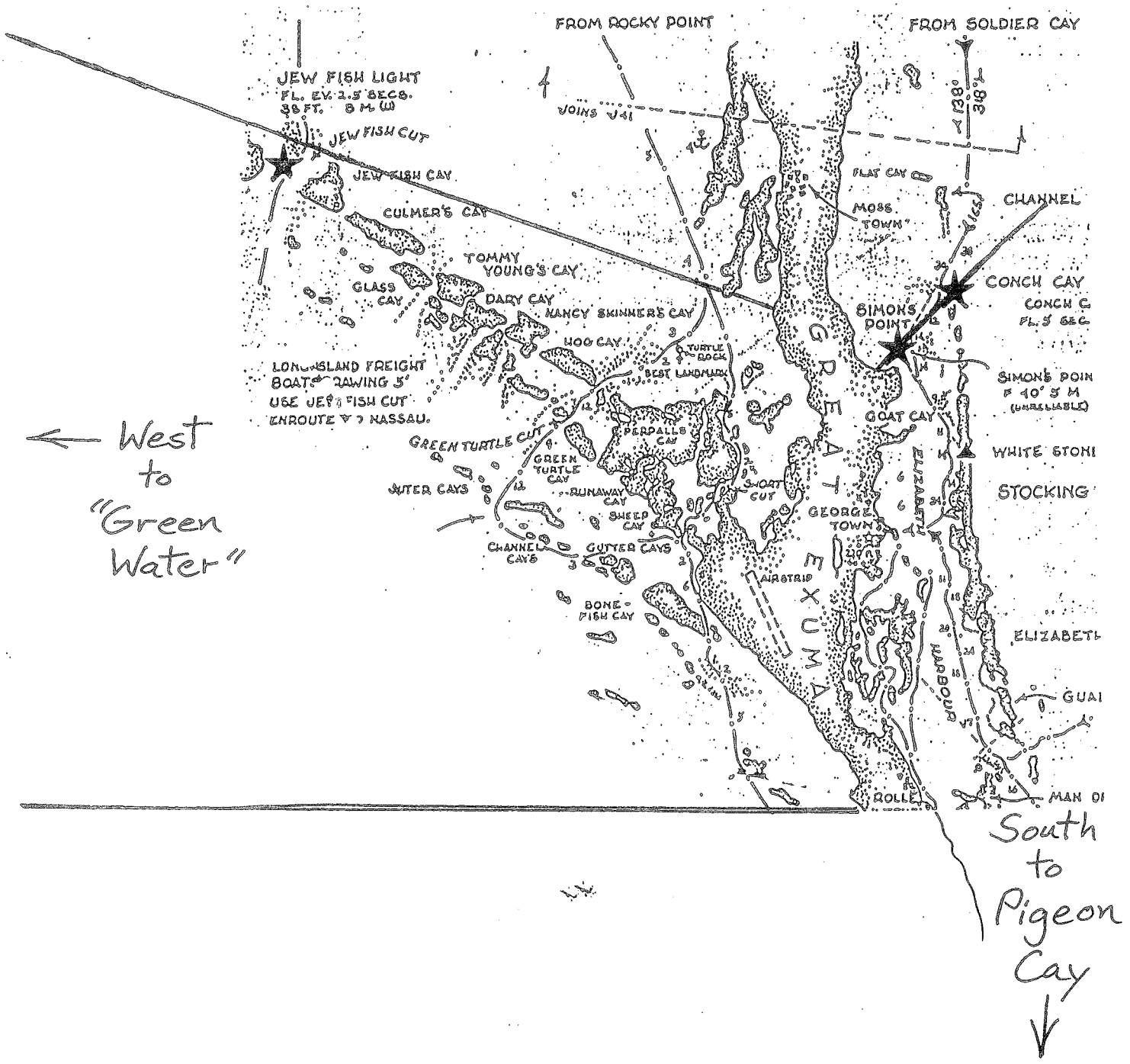
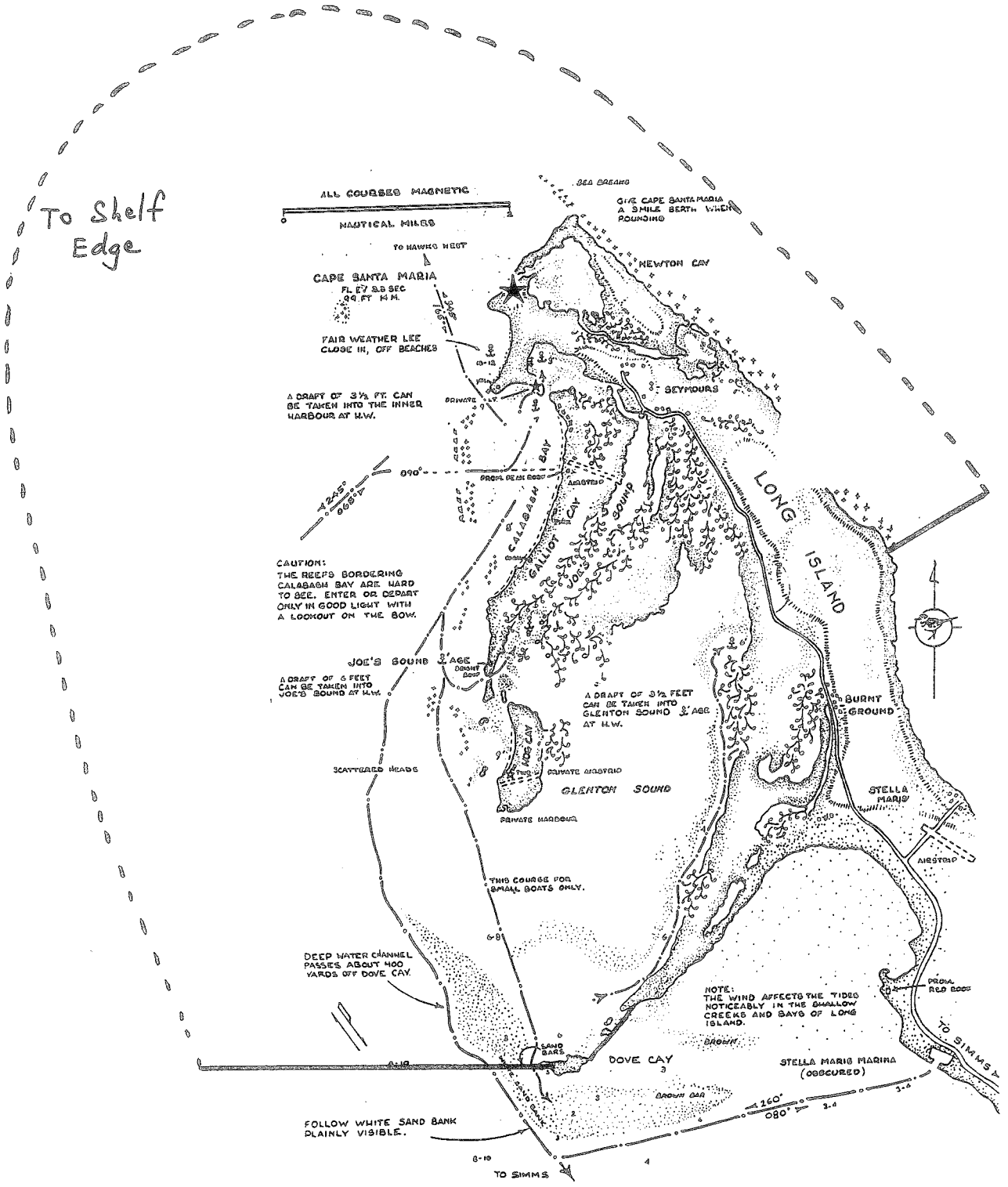


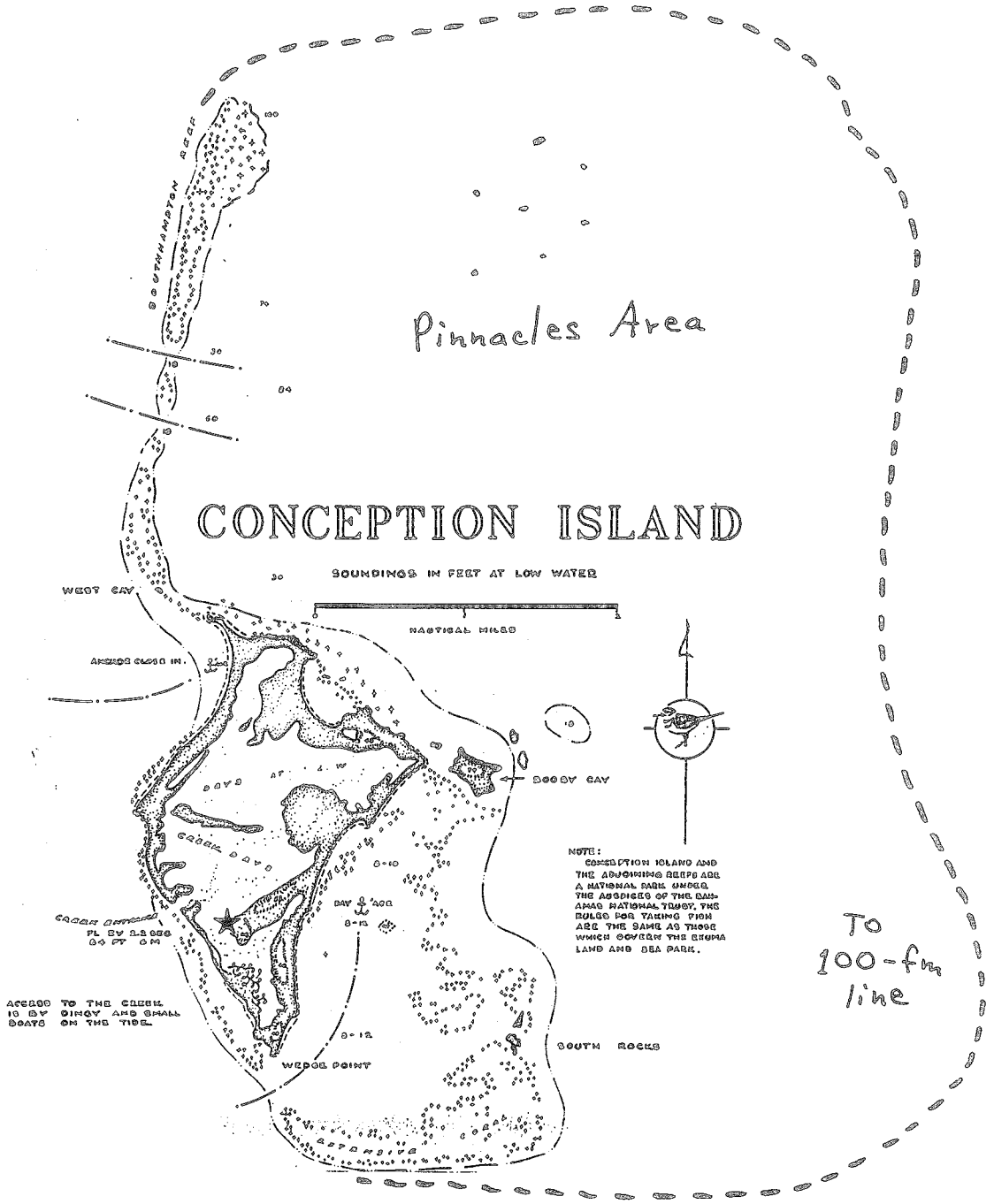
21: Long Island - North

This site includes an excellent mixture of windward and leeward coral reefs, and onshore seagrass and mangroves around Calabash Bay and Glenton Sound. Tidal channels flowing into the bay and sounds may provide important juvenile habitat for a variety of fish species and lobster. A grouper spawning aggregation site near Cape Santa Maria also makes this a very high priority site for protection. A dive operation at Stella Maris uses the reef in this area and may be supportive of a reserve.



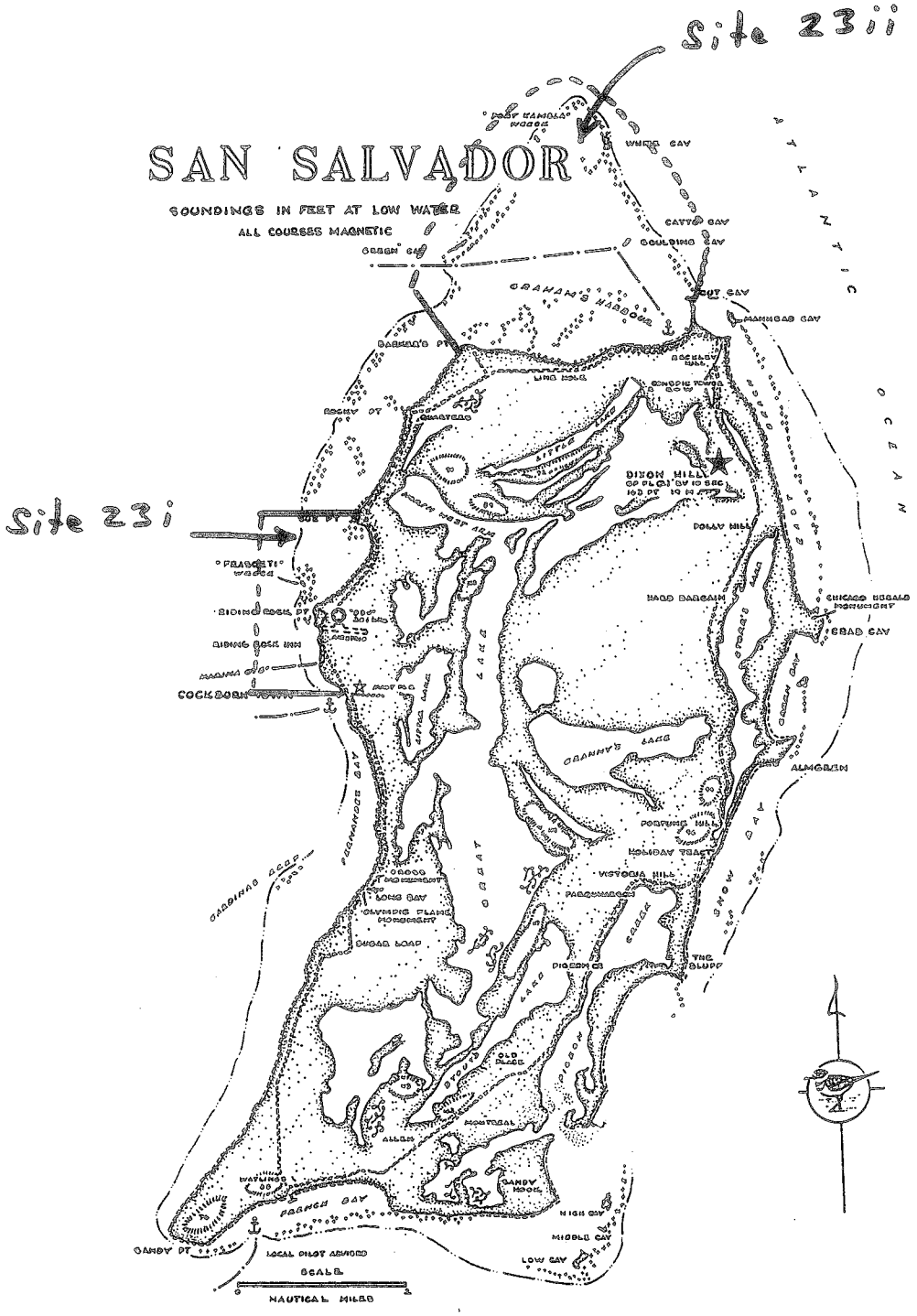
22: Conception Island

The island, approximately 2.5 miles long, is surrounded by relatively pristine coral reefs and seagrass beds to the south, east and north. A barrier reef extends 3 miles to the north and appears to be particularly healthy. Aerial surveys revealed dozens of sharp, pinnacle-form reefs in the area east of the island and barrier reef. This site already has some protection because of its status as a land reserve for migratory birds and nesting turtles administered by the Bahamas National Trust, and because of its remote location, exposure and lack of safe harbor.



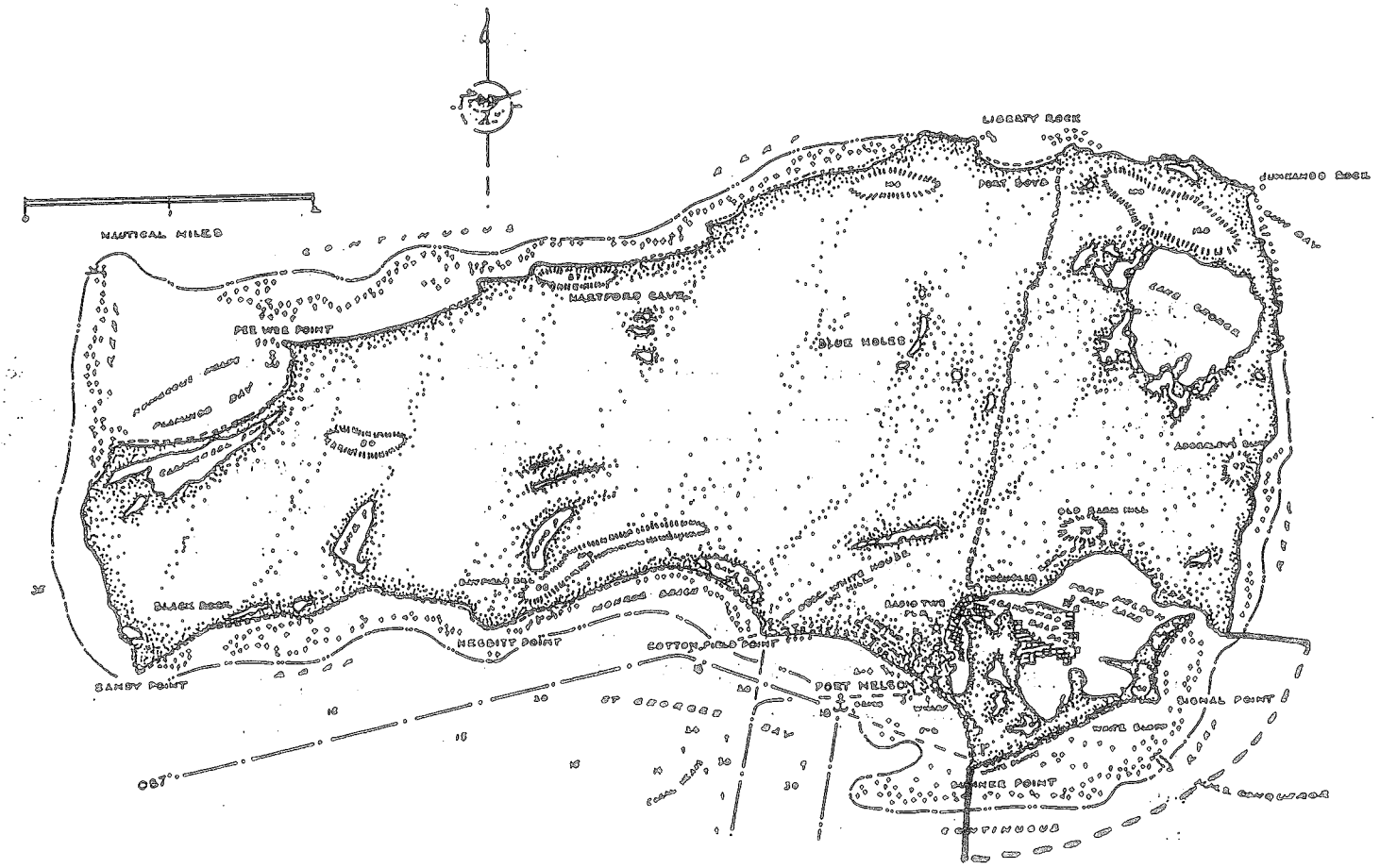
23(i): San Salvador - West, 23(ii): San Salvador - Northeast

The proposed marine reserve in western San Salvador (around Cockburn Town) is located in an area that is fished occasionally, but is used primarily by local dive boats. However the reefs are better developed in the north and east, which is less dived and fished because of exposure to rough weather. Both areas contain small patches of seagrass, and the island as a whole has extensive mangroves. In addition, San Salvador is home to the Bahamas Field Station which is located on the north shore.



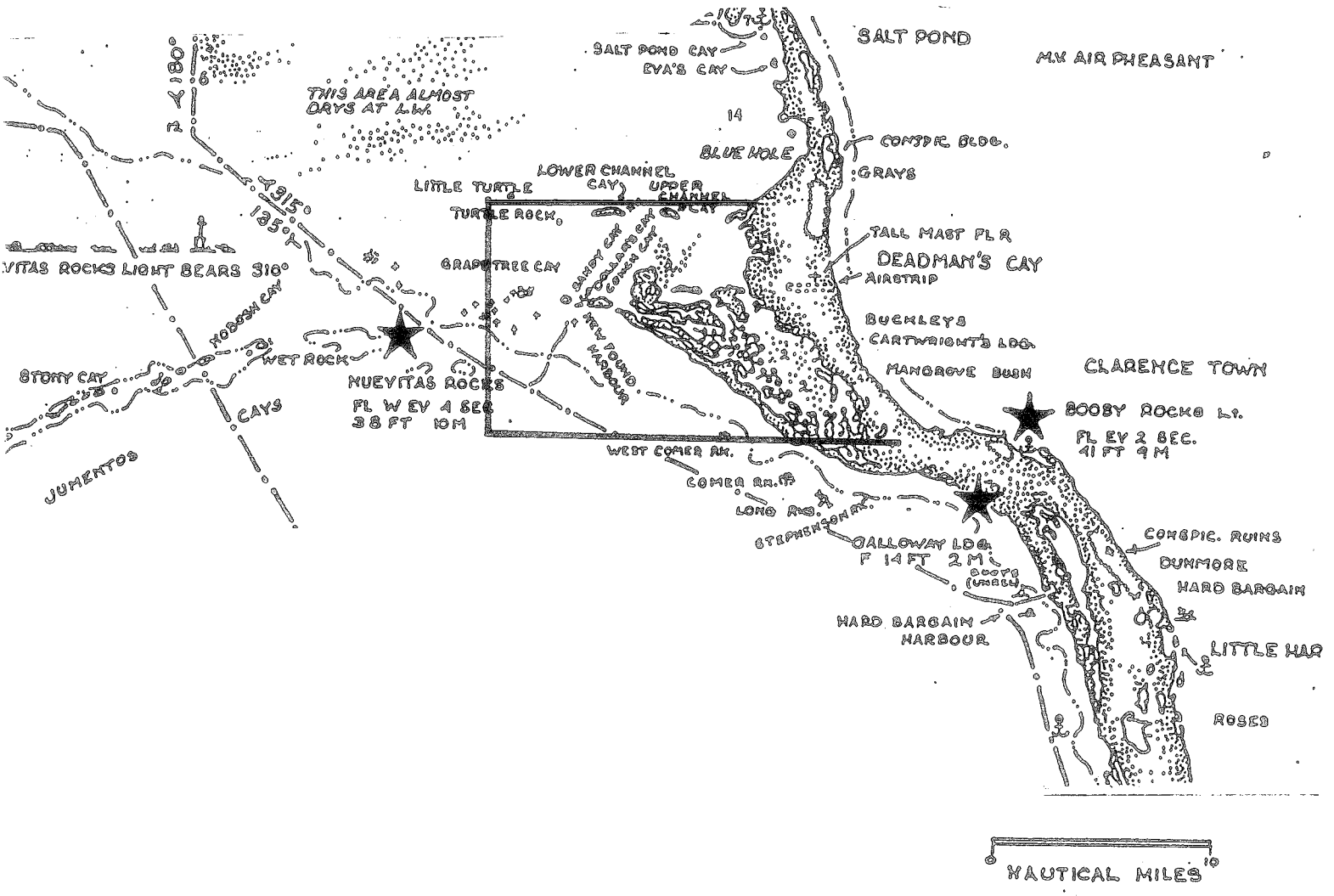
24: Rum Cay

The eastern side of Rum Cay has a relatively narrow shelf with extensive patch reefs inshore from the shelf edge. It also contains the entrance to the island's only lagoon system, which may contain important nursery habitats. South of Port Nelson, there are extensive sand areas. A reserve that includes some of the eastern shelf of Rum Cay may support local fisheries.



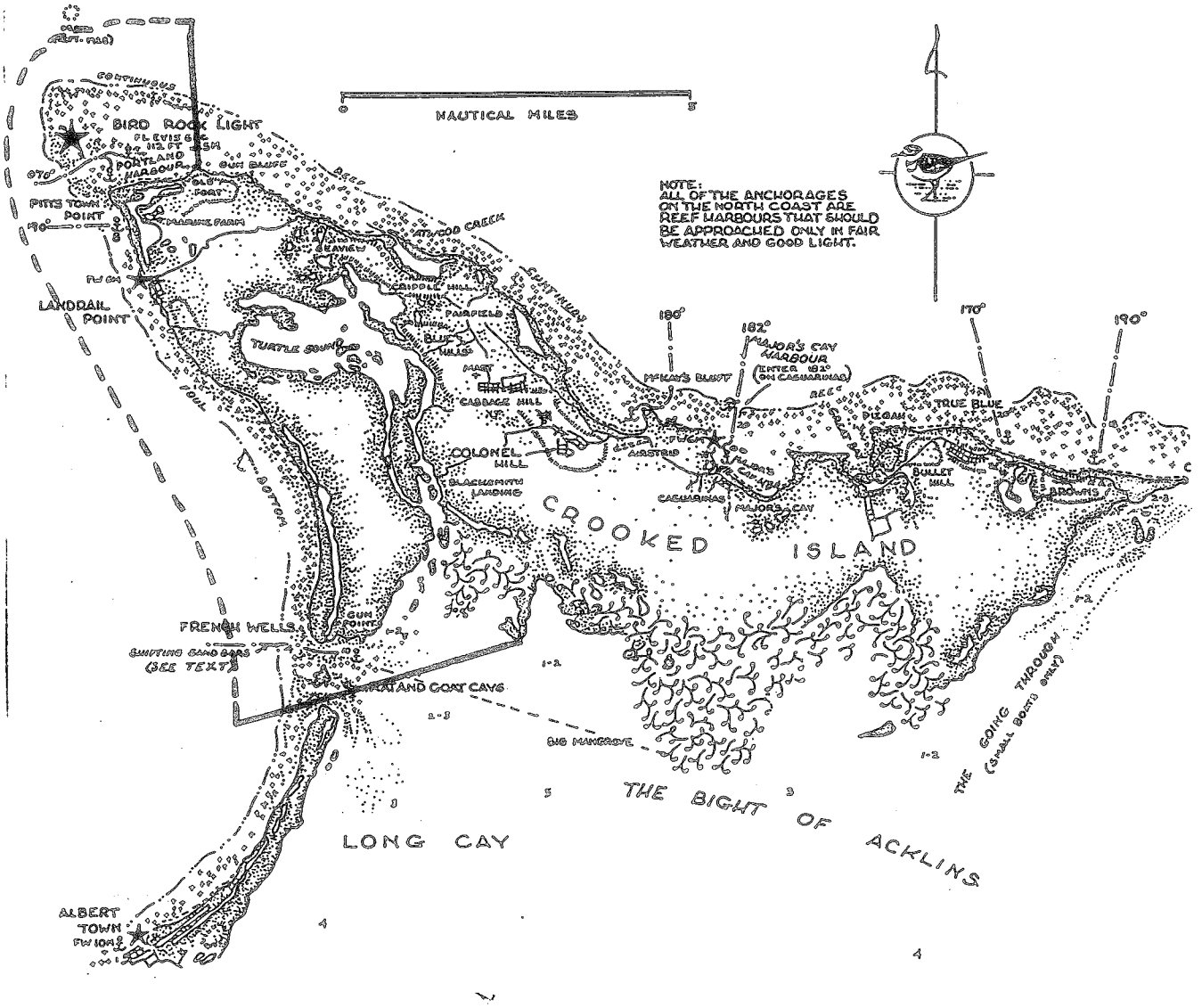
25: Long Island - Sandy Cay

The area around Sandy Cay on the west side of Long Island appears to contain primarily nursery habitat types such as mangroves, and possibly macroalgae and seagrass. Little information is available about nearby reefs, or the importance of any nursery areas within the boundaries of the proposed reserve.



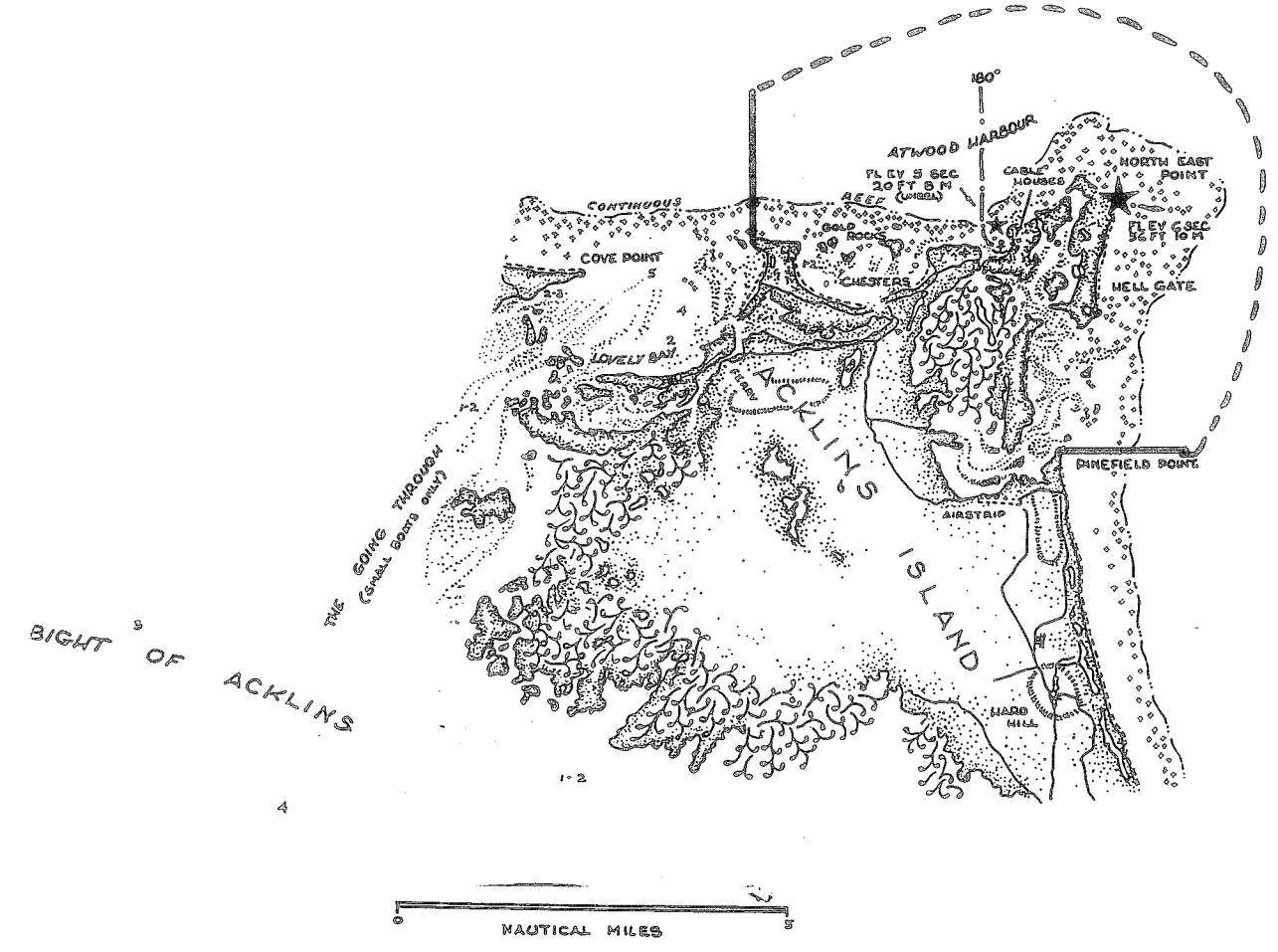
26: Crooked Island - Northwest

The reserve proposed at the northwestern corner of Crooked Island contains a section of the shelf which has patch reefs on a narrow shelf, plus a section of the mangrove fringed lagoon opening onto the Bight. The panel recommends that the reefs surrounding Bird Rock and Portland Harbor be included so that the most extensive reefs are protected, along with a spawning aggregation reported in that area.



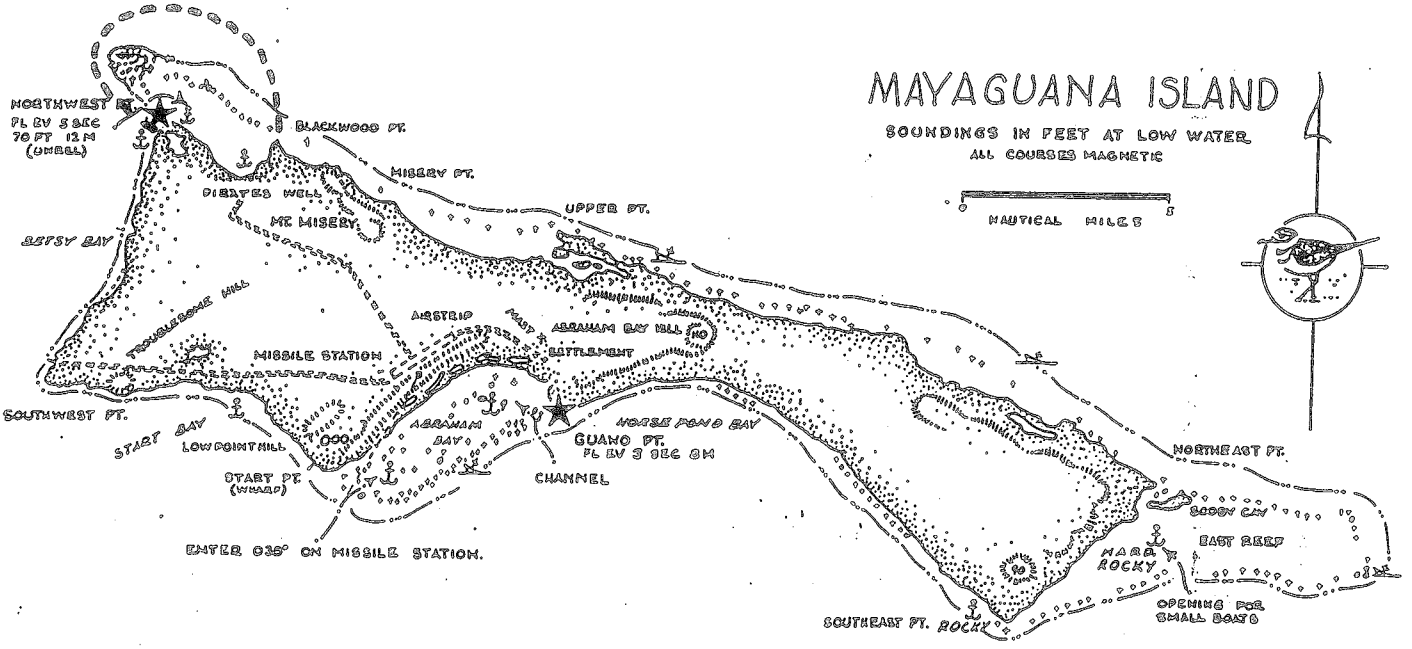
27: Acklins - Northeast

The northeast corner of Acklins Island has an intricate mixture of tidal channels, seagrass meadows, mangroves and reefs that should provide abundant habitat for juvenile and adult targeted species. A relatively small reserve could protect a high diversity of habitat in this system. There are reportedly problems with illegal fishing in the area.



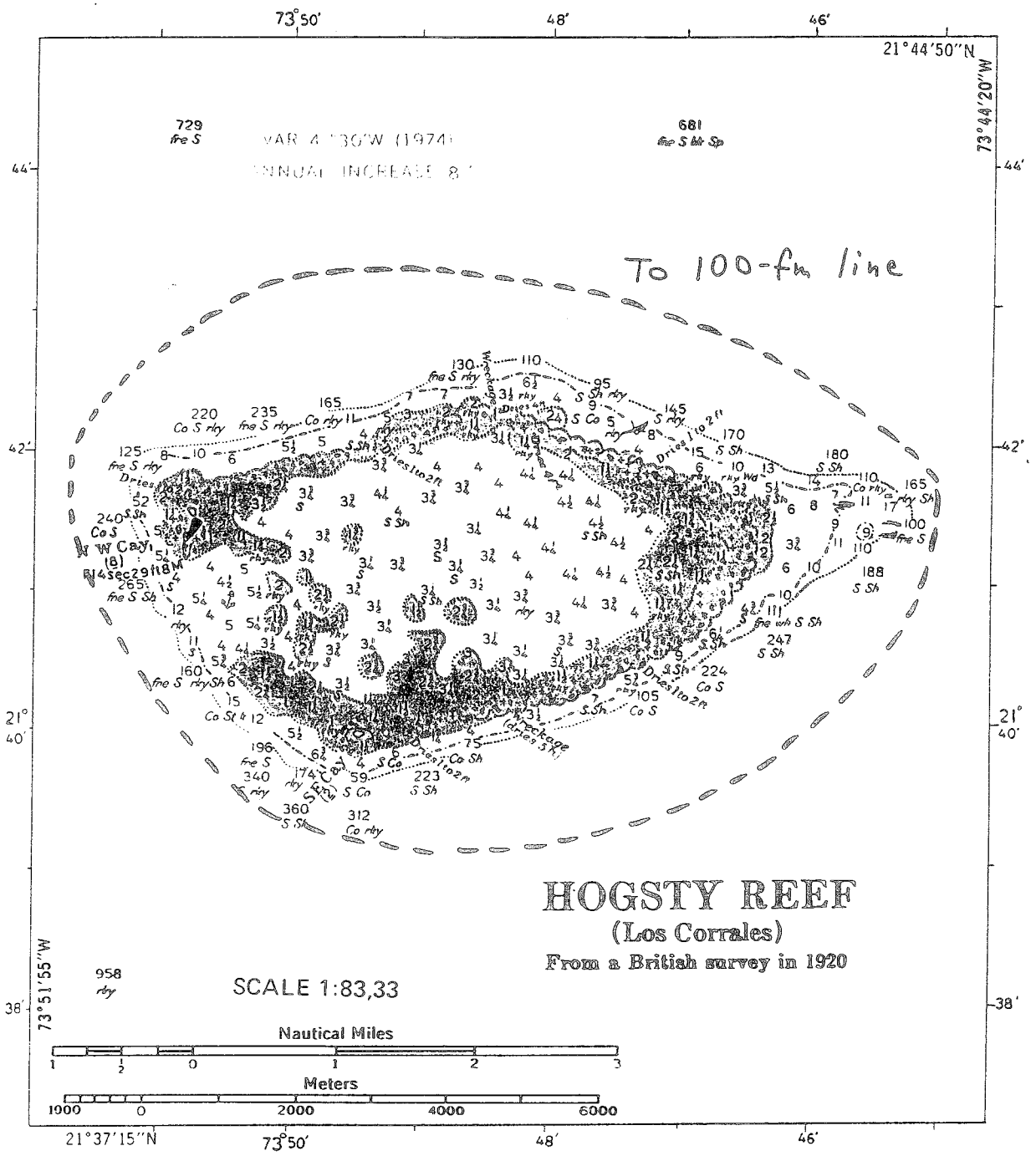
28: Mayaguana - Pirates' Well

The area between Pirates' Well and Northeast Point appears to contain a barrier reef and lagoon system. Because it is located near a settlement, it is likely to provide benefits to the local community, and may promote community participation in reserve management. There are repeatedly problems with illegal fishing in the area.



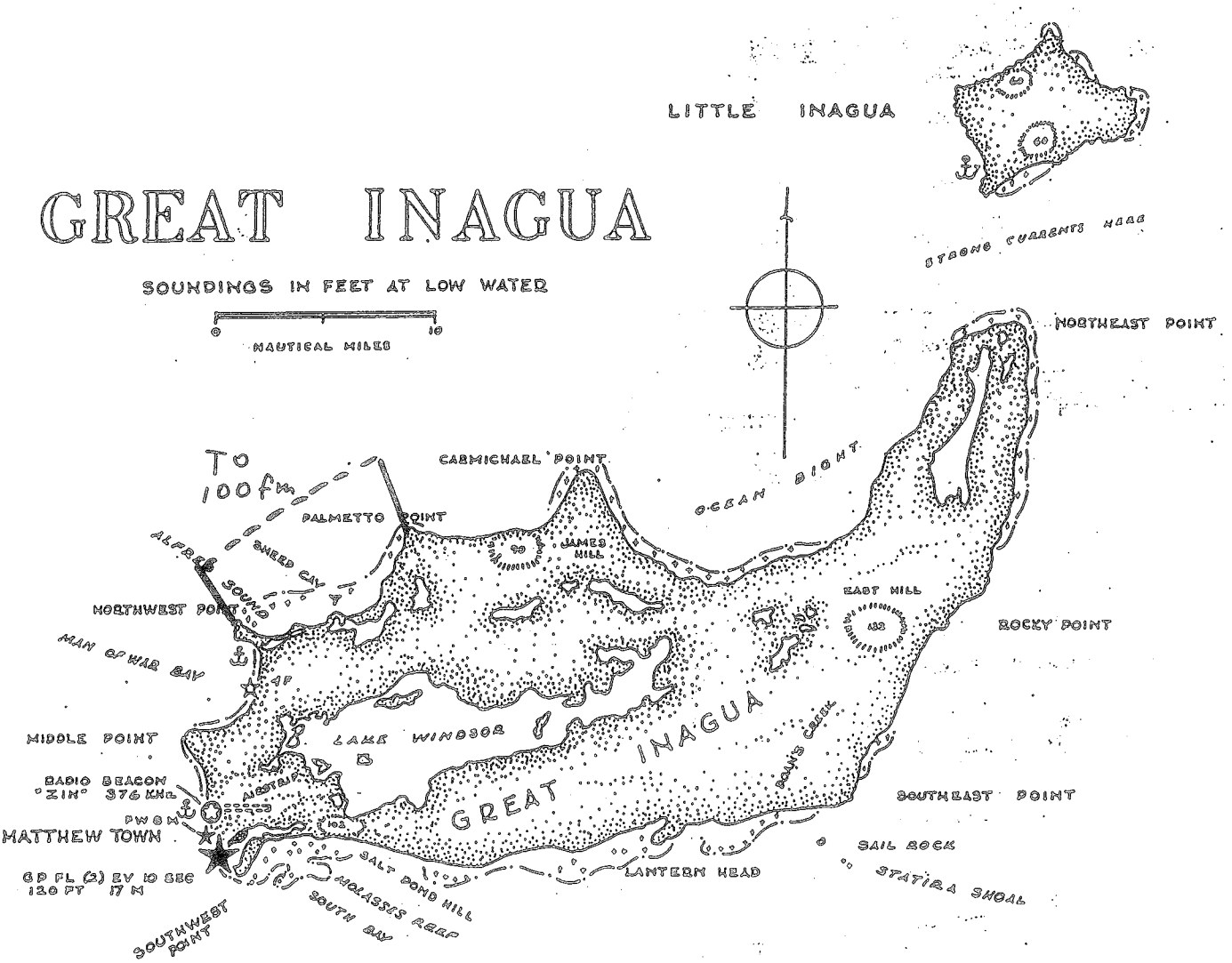
29: Hogsty Reef

This is a small (4-mile long) atoll-like coral reef formation between Acklins and Great Inagua. The reef is known for high fish diversity and should be protected as a truly unique habitat within the greater Caribbean region. There is no nearby community for monitoring this site; however, it is partially protected by its remote location and extreme exposure to ocean swell.



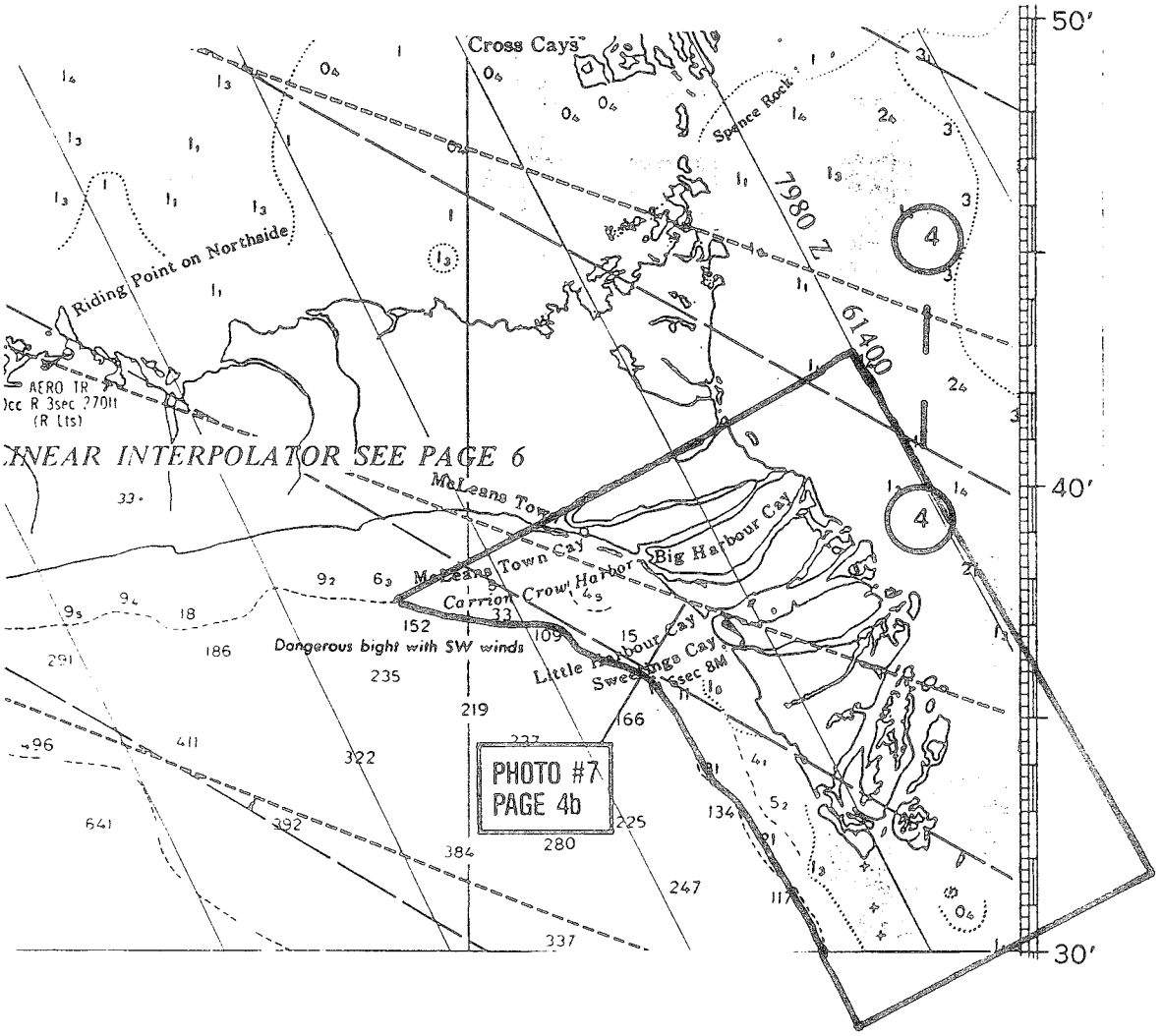
30: Great Inagua - North

The proposed reserve on the northwest corner of the island includes marine areas adjacent to the largest terrestrial park in the Bahamas. Habitats include reefs, seagrass, mangroves, and sandy beach. The southern position of the island gives it high potential for providing larvae to downstream nurseries.



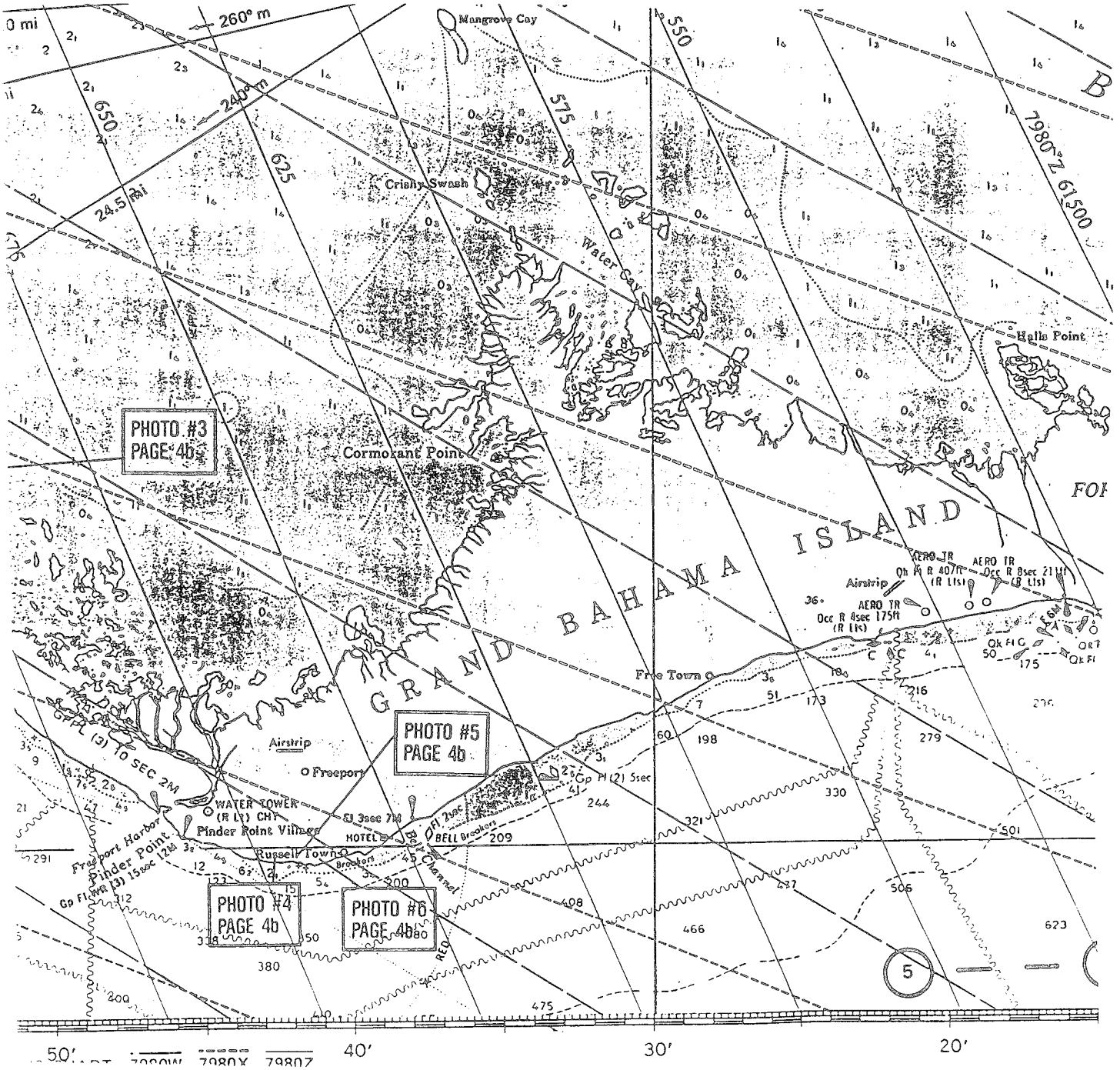
31: Grand Bahama - Sweetings Cay

This site is comprised of extensive mangrove islands separated by tidal channels with seagrass meadows along the western shelf and coral reefs and rock ledges to the west and south. This site appears to have abundant habitat for larger juvenile and adult conch, lobster and reef fishes, but may be heavily fished.



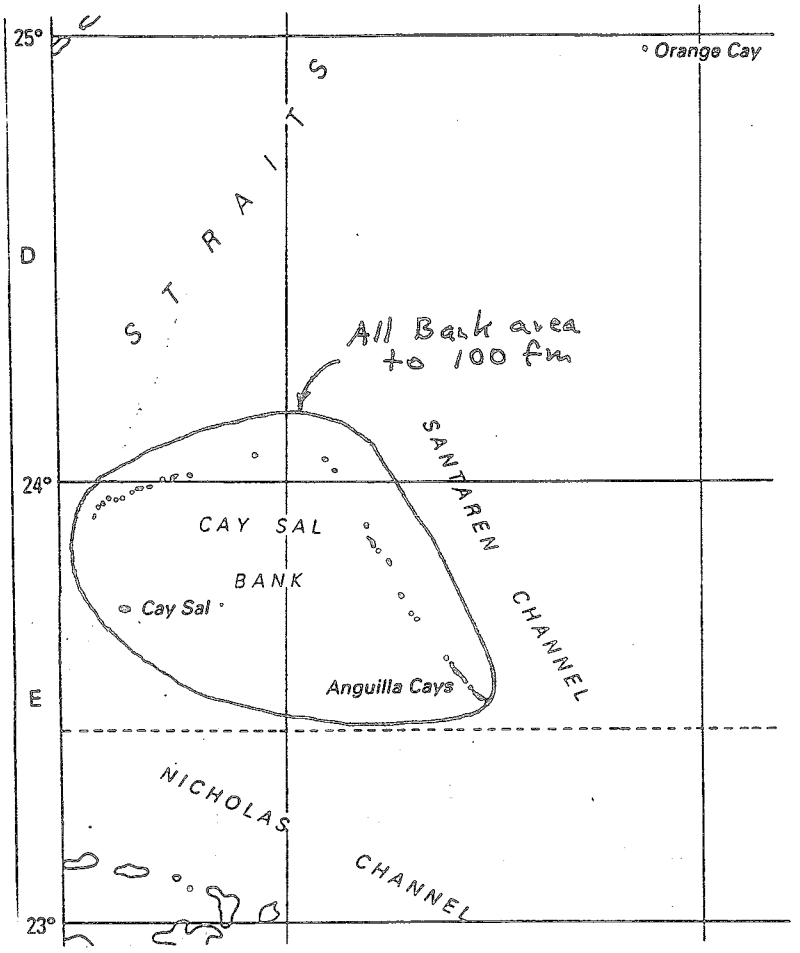
32: Grand Bahama - North

A marine reserve was considered for the north shore of Grand Bahama because of the existing land park (Lucayan National Park) and to provide another site on the Little Bahama Bank. However, this site has low habitat diversity, mostly sand and mangrove, and the potential for exporting larvae was considered to be low.



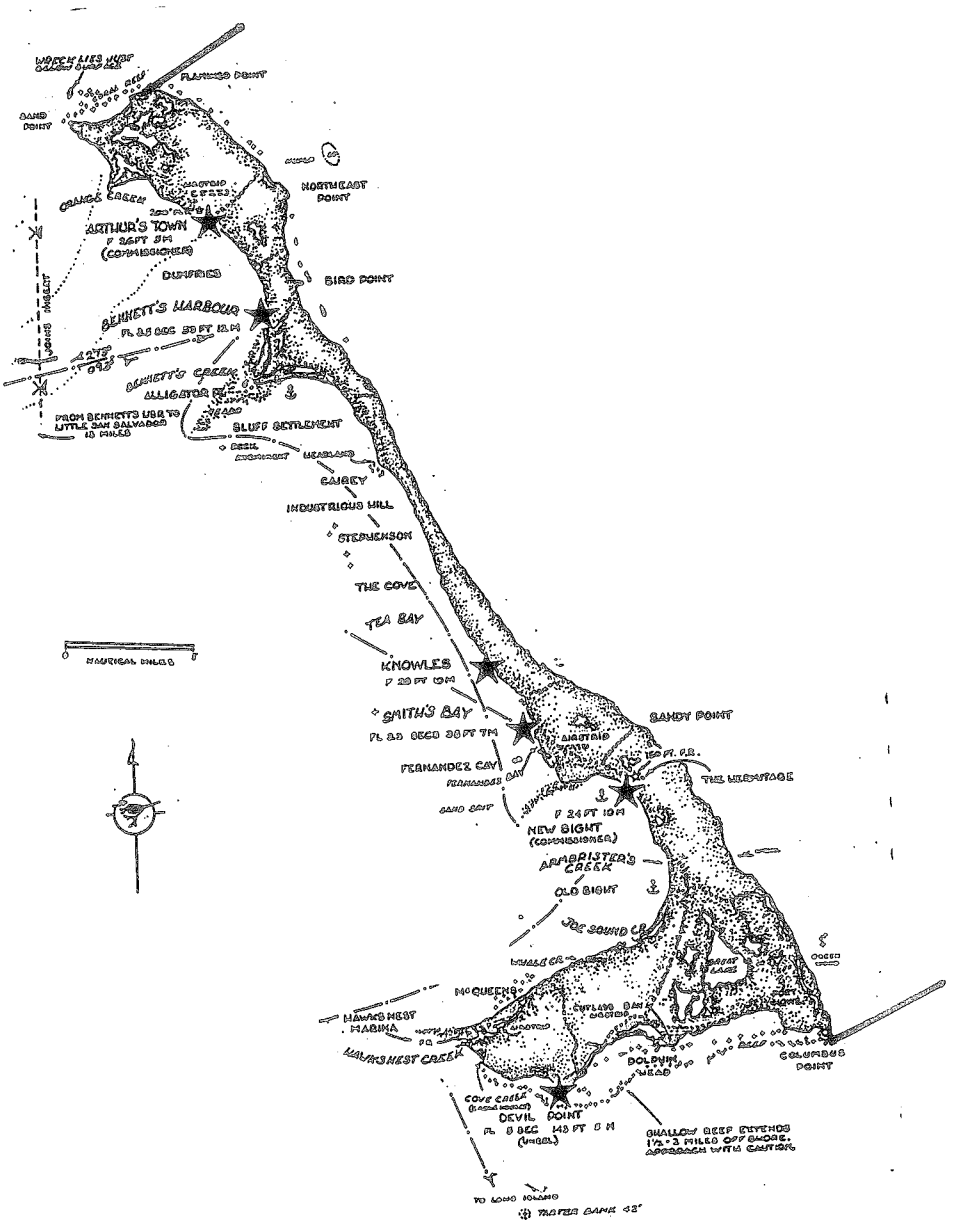
33: Cay Sal Bank

Little ecological information exists for this large bank to the west of the Great Bahama Bank. It appears to be fringed with coral reefs and its small cays are an important nesting area for several species of sea turtles. Because it is located far from inhabited parts of the Bahamas, and subject to foreign fishing pressure, it may be difficult to enforce a reserve in this area at the present.



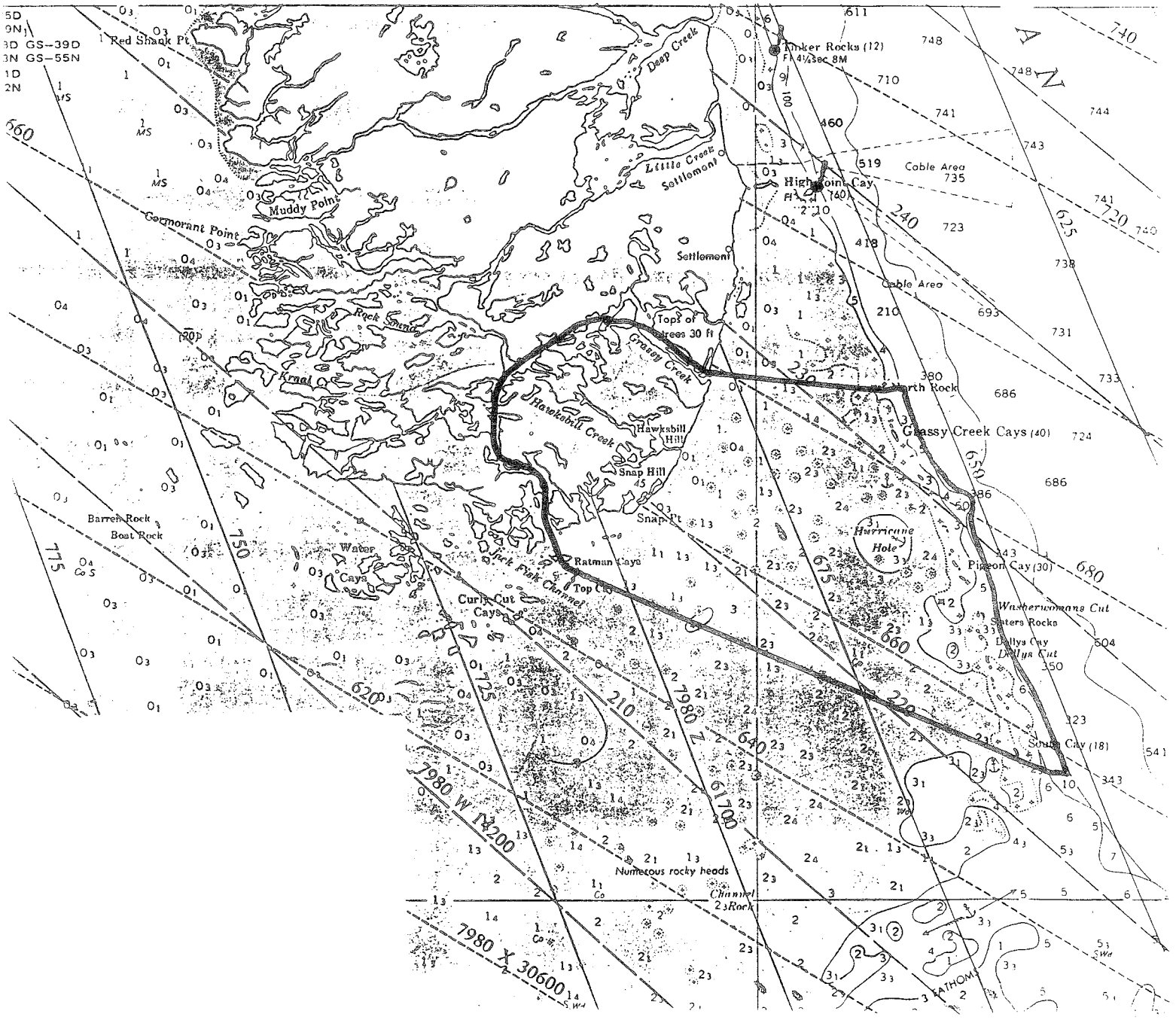
34: Cat Island - East

This site was observed by the panel while conducting aerial surveys around Cat Island, and newly identified as an important site for a marine reserve. Coral formations along the entire east coast of the island are among the very best and most extensive in the Bahamas, with large expanses of *Acropora* spp. close to shore. These species are currently under consideration for endangered status. The panel recommends that a minimum of 20 miles of the shelf be set aside as a marine reserve to protect this particularly pristine reef habitat.



35: Andros - South

This site includes a large triangular section of island shelf with coral reefs on the eastern boundary, seagrasses on the shallow shelf and abundant mangroves on the shoreline. This site was added by the panel because it contains abundant habitat for juvenile and adult stages of conch, lobster and reef fishes, and adds to the geographic context of the reserve network. There is also an unconfirmed Nassau grouper spawning aggregation in the proposed reserve area.



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35: Andros - South

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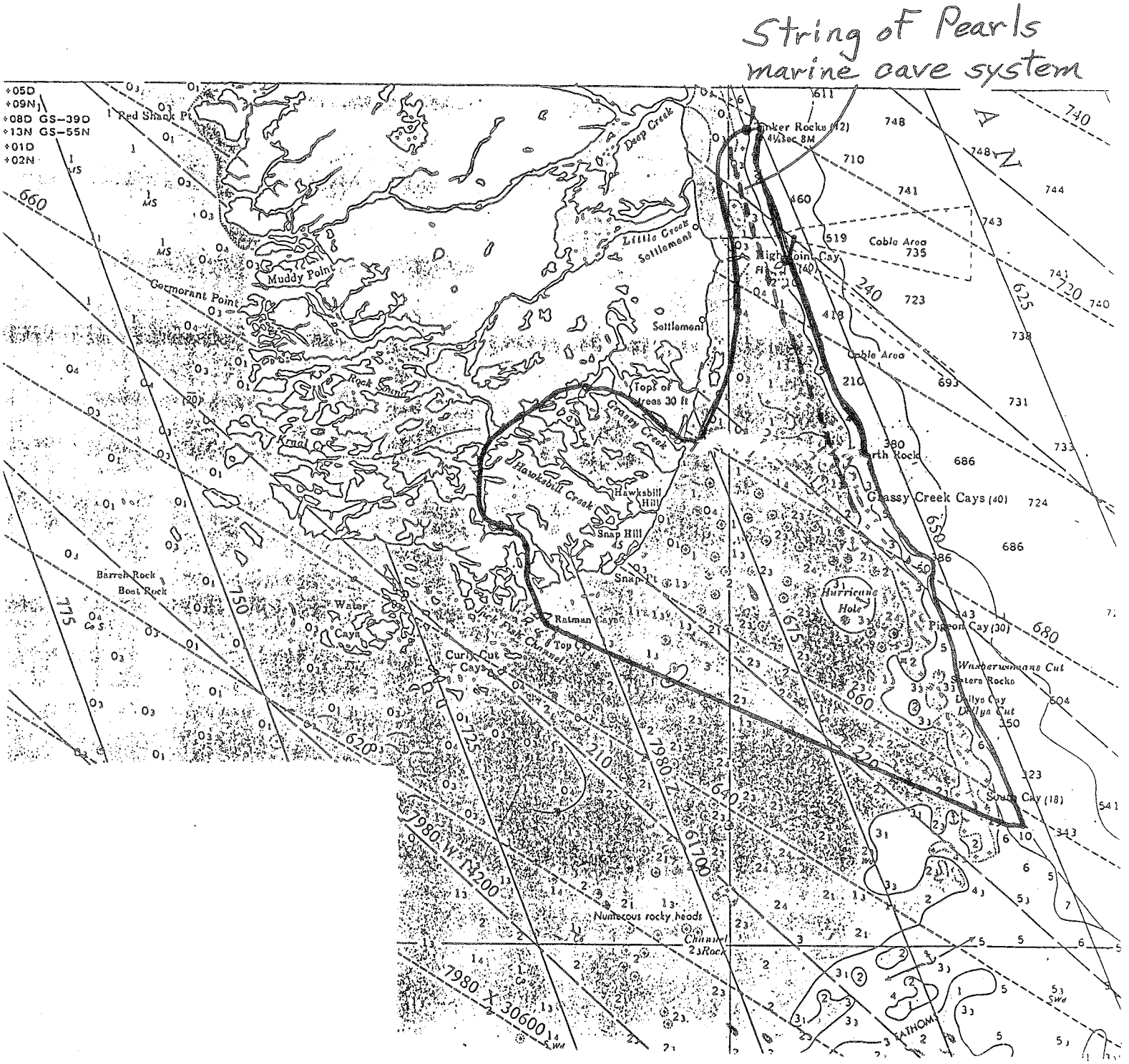
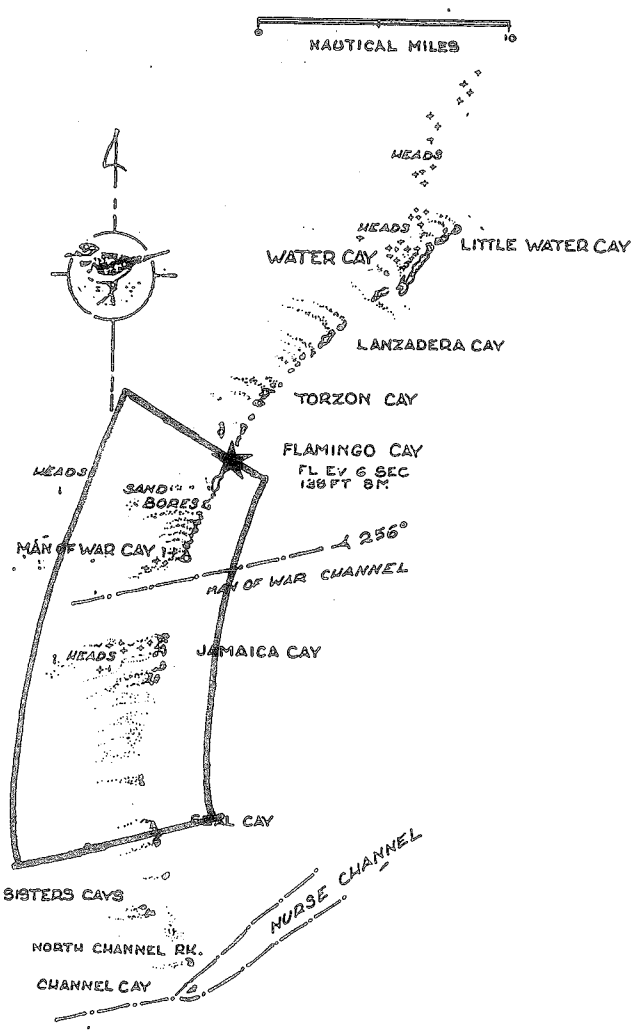


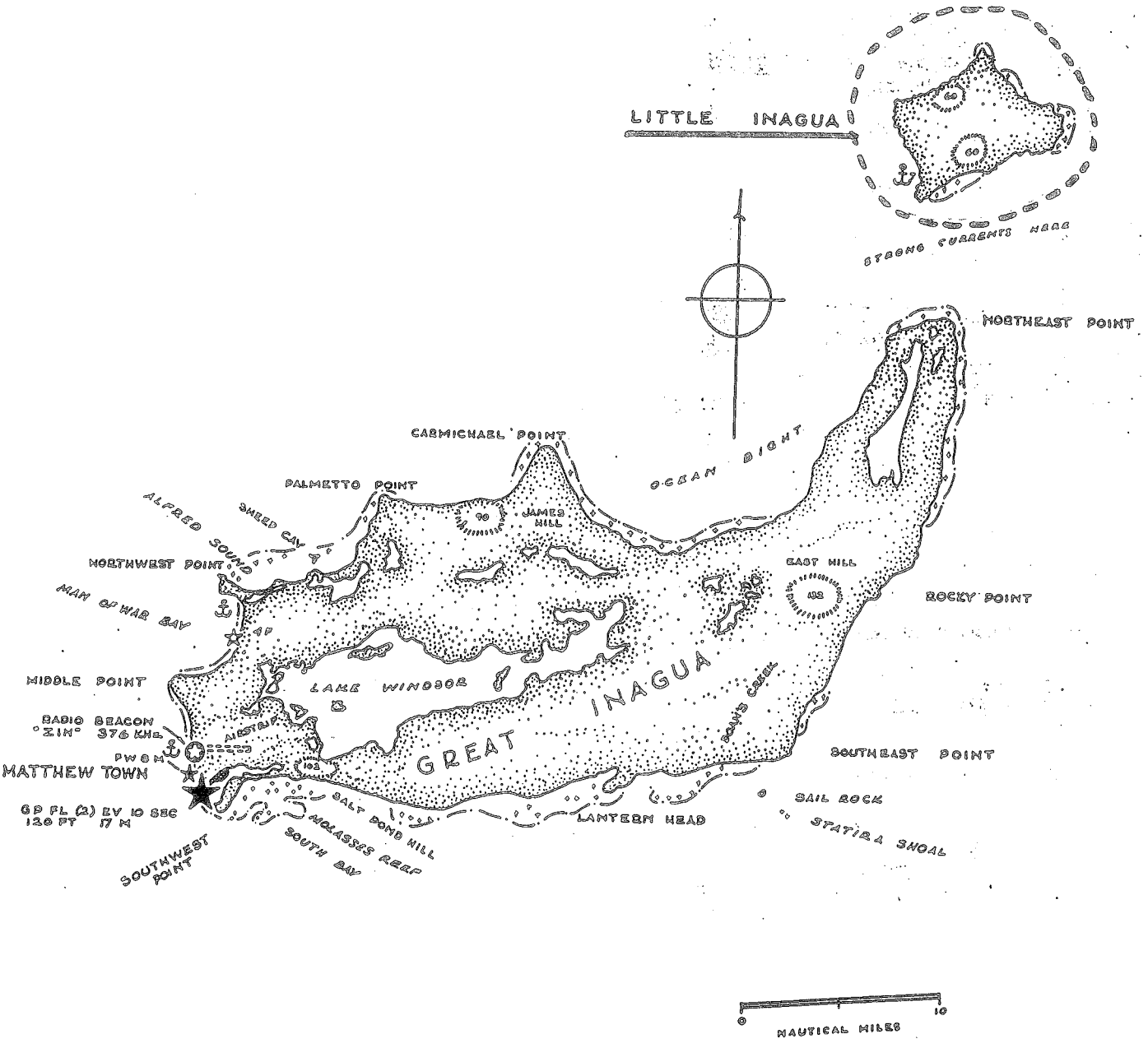
36: Ragged Island Chain - Central

The Ragged Island chain was recommended for inclusion in the marine reserve network by the Minister of Agriculture and Fisheries. The location of the reserve was suggested by the Department of Fisheries to minimize loss of traditional fishing grounds to the people of Ragged Island. The proposed area includes extensive bank areas out to the shelf edge, and its position should allow for larval export to other locations.



37: Little Inagua

This is the largest totally uninhabited islands in the greater Caribbean region, and the land area is being protected by the Bahamas National Trust. The marine habitats gain some degree of protection because of the remote location and lack of anchorage. Small coral reef areas occur at the eastern end of the island, and at the southwest corner. The panel was not able to visit this remote site.



Biographical Sketches of Scientific Review Panel

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Dr. Stoner is currently the chief of the Behavioral Ecology Branch at the Northeast Fisheries Science Center at the Sandy Hook Laboratory in New Jersey. He has long-term research experience on the distribution and ecology of marine fishes and invertebrates, and modeling habitat requirements. Dr. Stoner has spent more than 20 years conducting research in the greater Caribbean region, including four years at the University of Puerto Rico in Mayaguez, and more than 10 years working in the Exuma Sound region as the senior member of a large multidisciplinary program related to the fisheries ecology and recruitment of fishery resource species in the Sound. He was a full-time resident at Lee Stocking Island, Exuma Cays, for a period of five years, and has published more than 40 journal articles on queen conch related to research in the Bahamas, Florida, Venezuela, and Puerto Rico. Dr. Stoner is a regular technical advisor to the Caribbean Fisheries Management Council, and has provided fishery management advice to the governments of the Bahamas, the Cayman Islands, the Turks and Caicos Islands, and Colombia. He was a technical advisor associated with the development of the Declaration of San Juan drafted at the 1996 Queen Conch Conference directed toward an international agreement on the management of the queen conch resource.

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Dr. Hixon is a professor in the Department of Zoology at Oregon State University, where he teaches general ecology, marine ecology, and marine biology. His research expertise is marine ecology, focusing on coastal fishes in both temperate and tropical oceans. Emphasizing experimental studies underwater using SCUBA and manned submersibles, his research explores the question of what determines the number of fish in the sea, a problem of great interest to marine fisheries and conservation. He has completed substantial undersea research projects in California, Hawaii, Oregon, and the U.S. Virgin

Islands, as well as Australia, the Bahamas, and French Polynesia. Dr. Hixon's current research, funded by the U.S. National Science Foundation, focuses on mechanisms that drive and regulate population dynamics of reef fishes in the Bahamas. He has conducted this project at the Caribbean Marine Research Center at Lee Stocking Island, Exumas, since 1991. More recently, Dr. Hixon has become active in marine conservation issues, serving on scientific advisory panels to design and implement marine protected areas in California and U.S. associated coral reefs, and testifying before the U.S. Coral Reef Task Force and the Pacific Fisheries Management Council. He has received various honors as an effective teacher and public lecturer, and is a National Science Foundation Postdoctoral Fellow, a Fulbright Senior Scholar, and an Aldo Leopold Environmental Leadership Fellow. He serves on the editorial boards of three professional journals: *Coral Reefs*, *Ecology*, and *Ecological Monographs*.

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Dr. Dahlgren is currently a marine ecologist with the Center for Marine Conservation in Washington, DC. He has extensive experience in the fields of reef fish ecology and the design of marine reserves. He spent four years researching juvenile Nassau grouper habitat use, population dynamics, and recruitment in the Exuma Cays, Bahamas. He has also participated in several other research programs in the Bahamas including investigations into the population dynamics of spiny lobster, spiny lobster behavior, lemon shark behavior, chemical ecology of sponges in the Bahamas, and the effects of Hurricane Andrew on the Bahama Banks. Dr Dahlgren's current research focuses on marine protected area design and efficacy, with a focus on the use of reserves for managing tropical reef fisheries. He is also editing a book reviewing the global experience with no-take marine reserves. Dr. Dahlgren is on the Scientific and Statistical Committee of the Caribbean Fishery Management Council, the Educational Advisory Committee of National Geographic's Sustainable Seas Expedition, and is an advisor on marine protected areas for the government of the San Andres Archipelago, Colombia.

— ADDENDUM —

16 August 1999

The Honorable Dr. Earl Deveaux
Minister of Agriculture and Fisheries
P.O. Box N-3028 – East Bay Street
Nassau, Bahamas

re: additional information on marine protected areas

Dear Minister Deveaux:

This is in response to your request for more information at our meeting today. Up front, I want to thank you again for your vision of saving the beautiful Bahamian seas for posterity. I address each of your requests in turn: (1) explanation of revisions to the priority ranking of the proposed marine reserve sites, (2) methods for scientific assessment of the effectiveness of marine reserves, and (3) how to select which grouper spawning aggregation sites to protect.

(1) Revision of priority ranking of proposed marine reserve sites

Table 1 of the "Scientific review of the marine reserve network proposed for the Commonwealth of the Bahamas by the Bahamas Department of Fisheries" (Stoner, Hixon, and Dahlgren, July 1999) ranked proposed reserve sites by a combination of socioeconomic and ecological criteria. In the past month, I have gathered additional information from knowledgeable residents of Eleuthera (Doon and Casuarina McKinney), Exuma (Basil Minns), and Lee Stocking Island (Brian Kakuk) that has updated the scores of 5 sites, and therefore altered their priority ranks. Please refer to the legend for Table 1 in the original report for definitions of ranking scores.

Site 11: Eleuthera – Harbour Island: Reportedly, the communities in this region would favor a marine reserve, so the "community participation" score was upgraded from 2 to 3. This modification increased the total priority score from 4.83 to 5.17, placing this site in the top-priority list recommended for immediate designation. Note that this addition fills a geographical gap in the minimal network of reserves that scored 5.0 or greater.

Site 13(i): Eleuthera – Powell Point: Similarly, it was reported that the communities in this region would also support a reserve, so the "community participation" score was upgraded from 2 to 3. This modification increased the total priority score from 4.75 to 5.00. However, note that the alternative site 13(ii)—Powell Point to Schooner Cays—also rated 5.00, and is much more valuable ecologically, even though the level of community support for this larger reserve is unknown (community participation = 2). I recommend that the larger site 13(ii) be pursued.

Site 20(ii): Great Exuma – Jewfish Cays to Elizabeth Harbor: This is a new alternative site, an expansion of site 20(i)—Jewfish Cays only—so a new map was distributed at our meeting. Local support is reportedly high for including Elizabeth Harbor, which currently suffers from poor water quality due to excessive sewage, so "community participation" was upgraded from 2 to 3. Enhanced fish populations as well as increased tourism and recreational diving would be expected, so the "community benefits" score was upgraded from 1 to 3. Finally, including both

the west (Jewfish Cays) and east (Elizabeth Harbor) coasts of Great Exuma increased the "habitat diversity" score from 2 to 3. These changes increased the total priority score from 4.00 (site 20(i)) to 5.50 (site 20(ii)). These modifications place the alternative site within the highest ranked category recommended for immediate designation.

Site 23a: San Salvador – West: Reportedly, the resort on the west coast of San Salvador already treats this site as a reserve, so "community participation" was upgraded from 2 to 3. This modification increased the total priority score from 4.33 to 4.67.

Site 31: Grand Bahama – Sweetings Cay: The inclusion of two sets of marine blue holes and caves at this site—Zodiac Caverns and Great North Road—justifies adding an "ecological uniqueness" score to this site. These sites have already yielded a new class of crustacean (Remepedia), previously unknown to science. These and other marine cave systems of the Bahamas are also the source of marine sponges currently under examination by biomedical researchers for anti-cancer properties. The added ecological uniqueness score of this site increased the total priority score from 4.17 to 4.33.

Importantly, the above modifications increase the number of top-priority sites (overall priority scores of 5.0 or greater) from 13 to 15, adding sites 11 and 20(ii).

Additionally, the boundaries of proposed site 19 (Exuma Cays – Lee Stocking Island and vicinity) and site 35 (Andros – South) have been modified based on new information provided by Brian Kakuk, Basil Minns, and the Caribbean Marine Science Center. The new map of site 19 shows previously proposed boundaries that were unknown to the scientific review panel at that time we wrote our report. The new boundaries of site 35 include the ecologically unique "String of Pearls" blue hole and marine cave system, as well as additional fore- and back-reef habitats. These boundary changes do not change the priority scores of these sites, but certainly enhance the diversity of habitats within them.

(2) Scientific assessment of marine reserve effectiveness

From a fisheries perspective, there are two desired effects of marine protected areas: the *spillover effect* of increased abundance of adult fish (and shellfish) resulting in movement from reserves to adjacent fished areas, and the *seeding effect* of increased egg production within reserves enhancing recruitment of dispersing larvae to fished areas in the region. The former is much easier to document than the latter. In both cases, the most rigorous approach is to compare reserve and non-reserve areas both before and after substantial protection is implemented. All else being equal, the reserve and non-reserve areas will be similar before protection, and dissimilar in predictable ways as the spillover and seeding effects are manifested. Statistically rigorous sampling requires replicated sites that are stratified by habitat type (depth and habitat), as well as both randomly located and spatially fixed transects (or other samples). Appropriate statistical designs include analysis of variance, regression, and multivariate methods. Previous studies have shown that it may take a decade to document statistically significant effects of marine protected areas, due to the time it takes fish and shellfish populations to respond to protection.

To document whether a *spillover effect* occurs (which has been shown previously in the Exuma Cays Land and Sea Park, as well as Barbados and the Philippines), the approach is to measure fish abundance both inside the reserve and increasing distances from the reserve. The prediction is that, some time after protection is implemented, fish will be most abundant within the reserve, moderately abundant close to the reserve, and less abundant at increasing distances from the reserve. Fish abundance on reefs and other shallow, clear-water habitats is typically measured by visual belt transects, where the number of fish within a certain distance of a transect line is measured by divers.

To document whether a *seeding effect* occurs, the approach is to measure (1) the reproductive output via spawning inside vs. outside reserves, which is a relatively simple matter of measuring of biomass and fecundity (eggs per female) of adults (and which has been documented elsewhere), and (2) the ultimate abundance and location of larval recruitment due to that reproductive output (which has yet to be documented substantially). The challenge of the latter task is tracking eggs and larvae as they drift in the plankton away from spawning sites, following their path and survival until they settle to nursery habitats (reefs, seagrass beds, and mangroves). There are two novel methods for tracking larvae. First, for fish with demersal eggs (attached to the sea floor), the otoliths (ear stones) of pre-hatchlings can be tagged chemically with tetracycline. One then samples newly recruited juveniles throughout the region and hopes that chemically tagged fish are collected. To my knowledge, this method has worked on two occasions, but in my judgment, has a low probability of success (because the odds of recapturing a tagged fish are so low). Second, there are new dyes that can be tracked by sonar. Releasing the dye when and where fish spawn (e.g., grouper spawning aggregations), the drifting path of developing eggs and larvae can be tracked by a surface vessel. This method requires that the spatial association of dye and larvae be monitored periodically (using plankton tows), because the larvae can swim whereas the dye is inert. Despite the challenges of documenting the seeding effect, there are ample theoretical reasons to believe that it exists.

(3) How to select which grouper spawning aggregation sites to protect

Given the difficulty of measuring the seeding effect (see previous paragraph), it is difficult to predict which grouper spawning aggregations are most important to protect. Arguably, all aggregations are sacred because each represents the entire breeding stock of a region. When an aggregation is fished to extinction, that species become extinct in the region seeded solely by that aggregation. Therefore, my recommendation is that all spawning aggregations be fully protected during the entire breeding season. Short of that ideal goal, the most important aggregations will be those that (1) represent a large number of spawners and (2) are located such that they probably seed a substantial part of the Bahamas. For the latter criterion, sites centrally located in the southeastern part of a region are most likely to seed that region (because the prevailing ocean current through the Bahamas flows from southeast to northwest). Sluka et al. ("Habitat and life in the Exuma Cays, the Bahamas: the status of groupers and coral reefs in the northern cays," 1996) documented a peak in Nassau grouper abundance 35-40 km northwest of the Exumas Land and Sea Park, perhaps a result of the seeding effect.

I hope that this information is of use. In any case, I reiterate the recommendation of the scientific review panel that the marine protected areas of the Bahamas be permanent, no-take,

numerous, large, include a diversity of habitats essential for the life cycles of important sea life, protect those habitats, and provide broad geographic representation. Ultimately, the panel recommends that at least 20% of the productive shelf-edge habitats (reefs, seagrass beds, and mangroves) be designated as marine protected areas. The 20% figure is derived from fisheries models and data showing that, when a population is reduced by fishing to less than 20% of its virgin spawning biomass, it becomes highly probable that the population will go extinct.

I will be happy to be of service in any way that I can between now and my departure from the Bahamas on August 30, including a lecture on marine reserves. In the meantime, I will be conducting my research on the population dynamics of reef fishes at the Caribbean Marine Research Center on Lee Stocking Island (phone/fax: 242-355-5557).

It has been a distinct pleasure working with you, and I look forward to the next time. I also look forward to the possibility of the 2004 International Coral Reef Symposium being hosted by the Bahamas to showcase an unprecedented network of marine protected areas.

Best wishes,

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