Abstract

REPORT NO.9
Subtask 2.2

FISHERIES HABITAT OF THE VIRGIN ISLANDS REGION OF ECOLOGICAL IMPORTANCE TO THE FISHERY RESOURCES OF THE VIRGIN ISLANDS BIOSPHERE RESERVE

Ten habitat types in eight locations adjacent to the Virgin Islands Biosphere Reserve were selected and sampled for their resident assemblages of commercially important fish species. It is recognized that fishery stocks are distributed and interact without any consideration of man-made boundaries and thus, areas adjacent to the Biosphere Reserve may be ecologically important to the fishery stocks within the Biosphere Reserve. Habitat types which could have high ecological importance can be divided into two groups; nursery habitats (development and recruitment source for adjacent habitats) and reproductive habitats (production of eggs and larvae to supply nursery habitats). However, given the planktonic phase of most reef fish larvae and the migratory nature of the pelagic species of fish as well as conch and lobster, it is difficult to assess the actual influence of any particular reproductive site on the adjacent habitats.

The area sampled with the greatest potential for affecting fishery stocks in the Biosphere Reserve is the Coral Bay/Hurricane Hole area on St. John. Its importance as a nursery/juvenile refuge habitat is well documented and its location to windward (up current) of a large portion of the Biosphere Reserve makes the inter-relationship very strong. It is strongly recommended that this nursery/juvenile refuge habitat be considered as a protected area, particularly the Hurricane Hole portion of Coral Bay, as the National Park Service does have control over the coastland bordering these bodies of water.

Although the actual influence is not quantifiable, certain offshore habitats with high reproductive value (raised bank pavement for lobsters and fish; deep algal plains for conch) must also be considered in trying to put together the overall picture. These offshore habitats occur in both the United States and British Virgin Islands and may affect one as well as the other due to our proximity.

It is therefore recommended that the Virgin Islands Biosphere Reserve concept be expanded to consider some of the adjacent areas which may be inter-related with fishery stocks within the Biosphere Reserve. Research on actual inter-relationships, protection from development and management for sustainable yield are all of high importance.

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# FOREWORD

Virgin Islands National Park was designated as an International Biosphere Reserve by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in June, 1976. However, the formal dedication did not take place until May, 1983. The standardized, single-page description of the area which was issued by UNESCO under the Man and the Biosphere Program, MAB Project 8, in 1976 is entirely inadequate for the purpose of meeting Biosphere Reserve Objectives.

The purpose of the present (VIRMC I) project was to provide more detailed descriptions of the Reserve's physical and biological features as well as certain aspects of human use, such as fishing and boating. Inherent in the concept of the Reserve is the belief that it is intimately related to the nearby British Virgin Islands and that it should also fit within a future multi-site Lesser Antillean Biosphere Reserve.

The following reports are included in the VIRMC I Research Series Reports.

The West Indies Laboratory (Fairleigh Dickinson University) prepared the reports for "Ecological Community Type Maps and Biological Community Descriptions for Buck Island Reef National Monument and Proposed Marine Park Sites in the British Virgin Islands," "Trends in Recreational Boating in the British Virgin Islands, A Preliminary Assessment of Impact from Human Activities on Anchorages and Development of a Monitoring Program for Safe Anchorages," "Geographic Range and Research Plan for Monitoring White Band Disease," and "Marine Ecosystems of the Lesser Antilles - Identification of Representative Sites."

The Division of Fish and Wildlife (Department of Conservation and Cultural Affairs, Government of the U.S. Virgin Islands) prepared, " Map of Fishery Habitats Within the Virgin Islands Biosphere Reserve," "Fisheries Habitat of the Virgin Islands Region of Ecological Importance to the Fishery Resources of the Virgin Islands Biosphere Reserve," " Utilization of the Virgin Islands Biosphere Reserve by Artisanal Fishermen," and " Long-Term Monitoring of Fisheries in the Virgin Islands Biosphere Reserve."

The Caribbean Research Institute (College of the Virgin Islands) prepared, " Marine Community Descriptions and Maps of Bays Within the Virgin Islands National Park/Biosphere Reserve," and " Collection of Common Organisms Within the Virgin Islands National Park/Biosphere Reserve."

The Island Resources Foundation prepared, "Assessment of Fish and Shellfish Stocks Produced in the Virgin Islands Biosphere Reserve," "Socioeconomic and Cultural Role of Fishing and Shellfishing in the Virgin Islands Biosphere Reserve Area," " Characterization of Lesser Antillean Regional Fisheries," as well as the Synopsis and Executive Summary.

Field work for the project was carried out during the period December, 1983, through October, 1984. Copies of the individual reports can be obtained from: The Virgin Islands National Park, Red Hook Headquarters, P.O. Box 7789, St. Thomas, Charlotte Amalie, VI 00801.

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FIGURE

# 1. INTRODUCTION

The problem of delineation of fishery stocks, be they demersal fin fish, coastal migratory pelagics, conch or lobster, is very complex. None of these species observe geopolitical or other man-made boundaries. They are regulated purely through biological and physical factors. Biological factors include basic life history patterns; mode of spawning (demersal or pelagic), length of larval life, larval mobility, food requirements, and predator susceptibility. Physical factors include current patterns, island effects, upwelling and temperature/salinity/$O_2$ requirements. All of these factors combine to determine the distribution of the larvae and resultant distribution of the adults.

The Virgin Islands Biosphere Reserve (currently defined as encompassing all land and water owned by the National Park Service on St. John) has within it representative examples of nearly all tropical marine habitats (Beets and Lewand, 1985; Boulon, 1985). Given the situation as mentioned above, the V.I. Biosphere Reserve cannot be considered as a self-sufficient or closed system. While it can be accepted that interrelationships obviously exist between habitats within the Biosphere Reserve, consideration must be given to interrelationships existing between the Biosphere Reserve and habitats outside of its man-made boundaries.

It is generally accepted that nearly all important bony food fishes of western Atlantic reefs produce planktonic eggs (Colin, 1982). The one main exception to this is the trigger fishes. The most widely accepted reason for the production of planktonic eggs is the "Diminished Predation Hypothesis" (Sale, 1978; McFarland, 1982). This hypothesis holds that the production of pelagic larvae temporarily places the young out of reach of the predators commonly associated with shallow water reef habitats. As a secondary selective force favoring a pelagic larva, dispersion via a planktonic phase assures genetic mixing and colonization of reef habitats, which are usually patchy in distribution (Barlow, 1981).

In addition to demersal fin fish all other species of commercial importance have planktonic larvae. These include all the coastal migratory pelagic fish

(Centaur, 1982), lobster (CFMC, 1981) and conch (Randall, 1964), although conch lay an initial demersal egg mass from which a pelagic veliger larvae develops after five days (Brownell and Stevely, 1981).

In addition to a pelagic larval phase which could result in dispersion over vast distances, all the species considered here are capable of being quite mobile as adults. Reef fish are certainly capable of swimming long distances if so induced, pelagics are known to be highly migratory; conch are known to migrate often, possibly over great distances (Hesse, 1979); and lobsters engage in periodic mass migrations into deeper water (Kanciruk and Herrnkind, 1978).

This study is an attempt to determine if marine habitats adjacent to the Virgin Island Biosphere Reserve have any potential ecological importance to the fishery resources within the Virgin Islands Biosphere Reserve. Of all the habitats defined in these waters (Boulon, 1985) only two types of habitat, nursery and reproductive, could have significant effect on fishery resources within the Virgin Islands Biosphere Reserve. Nursery habitat has the potential for serving as a recruitment source for other habitats within the Virgin Islands Biosphere Reserve, while reproductive habitats have the potential of providing large quantities of larvae that will settle out of the plankton and develop in nursery habitats within the Virgin Islands Biosphere Reserve. From a concurrent study (Boulon, 1985) it was determined that the main marine habitat that can be classified as a nursery habitat is the shore mangrove zone, composed of submerged proproots of Rhizophora mangle. Reproductive habitats are found in the more offshore sites such as lower fore-reefs, bank patch reefs and raised areas of bank pavement (See Section 3.0 for descriptions) where the majority of larger, mature demersal fin fish appear to aggregate to spawn.

These areas serve as adequate reproductive habitat for demersal fin fish for several reasons. These include: good currents for dispersal of planktonic eggs and larvae, discrete areas of significant vertical relief which attract

large numbers of individuals from the surrounding featureless bottom and adequate shelter for individuals engaged in reproductive activities.

## 2. METHODS

Areas adjacent to the Virgin Islands Biosphere Reserve were selected for fishery resource sampling based on their proximity and potential for effect on the fishery resources of the Virgin Islands Biosphere Reserve (Table 1., Figure 1.). Primarily, potential nursery habitats or reproductive habitats were selected. These areas were mapped from aerial photographs at a scale of 1:5300. Areas adjacent to the Virgin Islands Biosphere Reserve in U.S. Virgin Islands waters are included on the maps in Appendix I of Boulon,1985. The maps produced by West Indies Laboratory for Subtask 1.3 were utilized for Norman Island (Anderson, et. al., 1985). Maps for Great Thatch and Soper's Hole, Tortola, were produced from NOS aerial photographs and are included in Appendix I of this report. Maps contain locations of all habitat types, however, only some of these were sampled for fishery resources in this study (Table 2).

Sampling for fishery resources was done either by random point visual census (Bohnsack and Bannerot, 1983; see description in Boulon, 1985) or compilation of species lists in areas where the census technique was not suitable (poor visibility or narrow habitat).

Due to the nature of this study, it was important only to define areas of significance either as nursery or reproductive habitats. This definition is based on the sexual state of the fish encountered (juvenile or adult). The criteria used for determining sexual state was size. The size range (minimum, maximum) was compared to published sizes for sexual maturity (CFMC, 1984) or to maximum attainable size and a determination was made as to sexual state. The few borderline cases may be in error.

TABLE 1

Locations adjacent to the Virgin Islands Biosphere Reserve sampled for fishery resources of ecological importance to the fishery resources of the Virgin Islands Biosphere Reserve. See Figure 1 for locations.

| Locations |
|---|
| 1. Pillsbury Sound, N.W., St. John, U.S. Virgin Islands |
| 2. Southwest St. John, U.S. Virgin Islands |
| 3. Reef Bay, S. St. John, U.S. Virgin Islands |
| 4. Otter Creek, Hurricane Hole, Coral Bay, St. John, U.S. Virgin Islands |
| 5. Western Norman Island, British Virgin Islands |
| 6. The Narrows, N.E. St. John, U.S. Virgin Islands |
| 7. Great Thatch, Little Thatch, West End, Tortola, British Virgin Islands |

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TABLE 2

Habitat types censused for commercially important fishery resources in areas adjacent to the Virgin Islands Biosphere Reserve. Acronyms used in all succeeding Tables. See text for description of habitat types.

| Habitat Types |
|---|
| 1. Sm - Mangrove Shore Zone |
| 2. Rfu - Upper Fore-reef |
| 3. Rfl - Lower Fore-reef |
| 4. Ba - Bank Algae |
| 5. Bp - Bank Pavement |
| 6. Bpr - Bank Patch Reef |

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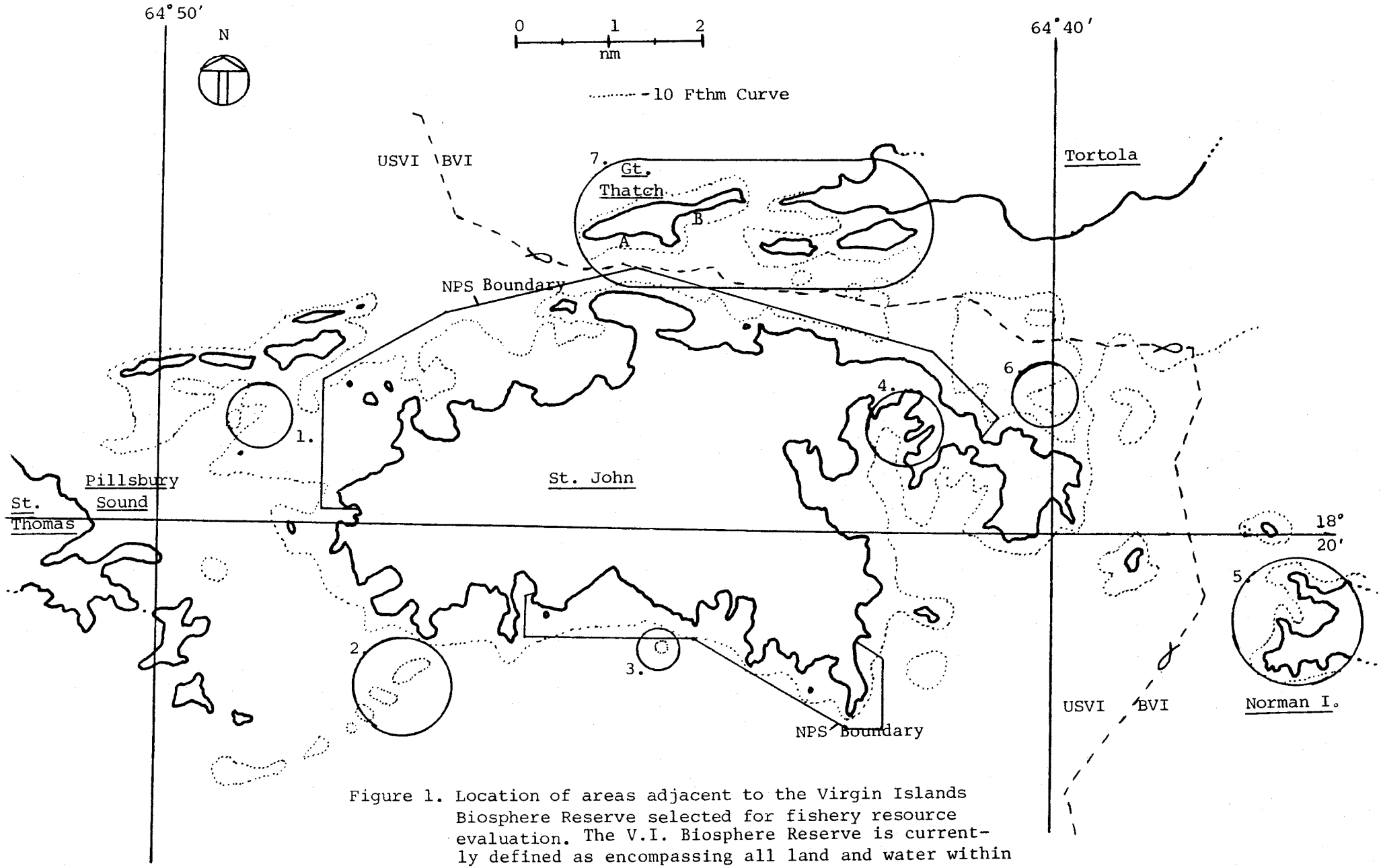


Figure 1. Location of areas adjacent to the Virgin Islands Biosphere Reserve selected for fishery resource evaluation. The V.I. Biosphere Reserve is currently defined as encompassing all land and water within NPS boundaries.

# 3. DESCRIPTION OF FISHERIES HABITAT ADJACENT TO THE VIRGIN ISLANDS BIOSPHERE RESERVE

## 3.1 Pillsbury Sound - Bank Algae - Ba

Just northwest of St. John lies a body of water called Pillsbury Sound, separating St. John from St. Thomas (Figure 1). This body of water is characterized by strong reversing tidal currents and sometimes rough surface conditions when the prevailing winds oppose the current. The currents are particularly strong in the narrow passages between the small cays and islands encircling the Sound. These currents passing into the Sound have resulted in the deposition of large sand mounds in various parts of the Sound. These sand mounds are sparsely colonized with algal species.

In the center of the sound (Location 1, Figure 1) is a large area of low, rolling mounds, approximately 40m to 50m in diameter, 20m deep on top and 25m in the valleys. These mounds are densely colonized with algae, sponges and a few species of coral, providing little structural complexity. This provides little shelter for fish of any size. As a result, the majority of fish are small, cryptic species with no commercial value. The only fish seen of commercial importance was a juvenile queen triggerfish (Table 3).

It may be that this habitat serves as a nursery habitat for some species of commercial importance such as the queen triggerfish. Juveniles are quite hard to detect as they would blend into the background mosaic of sessile organisms. More work needs to be done in these areas before any conclusive statements can be made.

## 3.2 Southwest St. John - Bank Pavement - Bp

Southwest of St. John, starting due south of Bovocoap Point, lies a series of raised hardbottom (Bank Pavement) areas stretching out to the southwest (Figure 1). These raised areas of Bank Pavement were observed to have extensive undercutting around the edges, providing a fair amount of shelter for fish and lobsters. Depths are generally over 20m and invertebrate cover is sparse (5-10%). Sponges,

TABLE 3

Locations adjacent to the Virgin Islands Biosphere and the fish species observed in each. Species observed either in a census or a species list. Habitat type acronyms defined in Table 2. J=Juvenile, A=Adult.

| HABITAT TYPE / LOCATION | PILLSBURY SOUND USVI | SOUTH ST.JOHN USVI | REEF BAY USVI | HURRICANE HOLE USVI | NORMAN ISLAND BVI | | NORTHEAST ST.JOHN USVI | GREAT THATCH ISLAND BVI | | SOPER'S HOLE BVI |
|---|---|---|---|---|---|---|---|---|---|---|
| FISH SPECIES | Ba | Bp | Bpr | Sm | Rfl | Sm | Bp | Rfu | Rfl | Sm |
| Kingfish | | A | | | | | | | | |
| Carang | | A | A | A | A | J | | | J | |
| Queen Triggerfish | J | A | A | | A | | A | | | |
| Blue-striped Grunt | | A | A | J,A | | J,A | A | A | | |
| White Grunt | | | A | J | A | J,A | | | | |
| French Grunt | | A | A | J,A | A | J,A | | J,A | A | J |
| Tomtate | | | | J,A | A | J | A | J,A | | J |
| Juvenile Grunts | | | | J | | J | | | | J |
| Dog Snapper | | | | J | | | | | | |
| Grey Snapper | | | | J,A | | | A | | | A |
| Schoolmaster | | | A | J,A | | | A | A | | J,A |
| Yellowtail | | A | A | J,A | | J | A | | J,A | J |
| Mahogany Snapper | | | | J,A | | J,A | | J,A | | |
| French & Queen Angelfish | | | | J | | | | | | |
| Grey Angelfish | | A | J,A | | | | J,A | | | |
| Rock Beauty | | | | | A | | | | | |
| Red Hind | | | A | | A | | A | | | |
| Graysby | | | | | A | | | | | |
| Coney | | A | A | | | A | A | | | |
| Nassau Grouper | | | A | | | | | | | A |
| Tiger Grouper | | | | | J | | | | | |
| Porgies | | | | J | | | | | | |
| Doctor Fish | | A | A | J,A | J,A | J,A | A | J,A | A | |
| Yellow Goatfish | | | | J,A | A | J,A | | A | | |
| Spotted Goatfish | | | | J | A | | | | | |
| Spanish Hogfish | | A | J,A | | | | | | | |
| Parrotfish | | A | J,A | J,A | J,A | J,A | J,A | J,A | J,A | J |
| Trunk Fish | | | A | | | J | | | | |
| Barracuda | | | | J | | | | | | J,A |
| Mullet | | | | | | | | | | A |
| Squirrel Fish | | A | A | J,A | A | J,A | A | A | A | |
| Mojarra | | | J,A | J | | | | A | | J |
| Blue Fry | | | | J | | | | J,A | | |
| Conch | | | | J | | | | | | |
| Lobster | | A | | J | | | A | | | |
| TOTAL NUMBER FISH SPECIES | 1 | 12 | 17 | 21 | 14 | 14 | 12 | 11 | 6 | 11 |

gorgonions and some coral species were present. It is unknown how much of the insular shelf south of St. John is comprised of this habitat. If more occurs than this one string of raised areas it would have to be deeper than 20m, as none appear on the nautical charts.

Centaur (1982) describes 90 percent of the Virgin Islands shelf region as a former Pleistocene back-reef lagoon type environment. There exists a well-defined shelf edge reef with scattered patch reef pinnacles and underlying bedrock outcrops in the submerged back-reef portions of the bank. Barren inter-reef areas are described as being dominated by calcareous nodules which do not provide attractive habitat to very many species of fish.

This habitat may serve as a very important offshore mature reproductive habitat for several reasons. These include: good currents for dispersal of planktonic eggs and larvae, discrete areas of significant vertical relief which attract large numbers of individuals from the surrounding featureless bottom and adequate shelter for individuals engaged in reproductive activities. All twelve of the commercially important species of fish that were observed in this habitat were large, mature size (Table 3). This appears to be a primary habitat for adult individuals of queen triggerfish. Additionally, it appears to serve as a daytime refuge for some species of grunts which forage on the surrounding sand and algal flats at night.

In addition to fish species, this bottom feature provides good shelter for lobsters. Most of the numberous lobsters encountered here are large, mature individuals (carapace length greater than 9cm). Many local divers frequent this bottom feature to obtain lobsters. This may also serve as an important reproductive habitat for lobsters for the same reasons as given above for demersal fin fish, however, whether this has any effect on fishery resources within the Virgin Islands Biosphere Reserve is unknown (see Discussion).

### 3.3 Reef Bay, St. John - Bank Patch Reef - Bpr

Due south of White Cliffs, Reef Bay, a large (200m + diameter) circular patch reef rises out of a sand/algal plain in 25m of water to 15m of water on top. This bank patch reef is approximately 100m outside of the National Park Service boundary (Figure 1). The upper surface of this patch reef is nearly flat with sessile invertebrate cover lower than on the sides. The sides are nearly vertical which enhances sediment removal and allows for better coral growth. Coral species present are of the deeper water species assemblage and colony morphology.

This bank patch reef appears to serve as an island of refuge in the middle of an otherwise flat bottom having little or no vertical relief. As such it harbors many fish that seek vertical structure to provide shelter from predators. Some of these species (grunts, snappers) may venture off the reef at night to forage in the surrounding grass/algal flats. The migrations are twilight events that may reduce both predation and competition (McFarland, et. al., 1979).

Seventeen species of commercially important fish were observed on this bank patch reef (Table 3). Nearly all were present solely as adults, indicating that this habitat may serve as a mature, reproductive habitat for nearly all the species observed. This particular bank patch reef has already been documented as a spawning location for a common species of parrotfish and others (Randall and Randall, 1963). Colin and Clavijo (1978) describe a "superior" spawning site at the most seaward extension of a reef having the best opportunity for planktonic eggs to reach the offshore circulation systems. Using this criterion, this bank patch reef would have qualities exceeding those of the inshore reef extension described above.

As a refuge, this reef may serve as an important habitat for many species of fish that forage within the Virgin Islands Biosphere Reserve. As a reproductive habitat, this reef may serve as an important source of planktonic larvae which may recruit into the populations of demersal fin fish found within the Virgin Islands Biosphere Reserve, depending upon current patterns and longevity of planktonic larval phases (see Discussion).

While none were seen during the observation periods on this reef, it is reasonably certain that this bank patch reef supports relatively large populations of lobster. The habitat is such that there is good shelter for lobster. Good currents make food available and the location is also ideal for spawning activities. Divers' reports confirm the presence of lobsters in this habitat.

### 3.4 Hurricane Hole, St. John - Mangrove Shoreline - Sm

Coral Bay, on the east end of St. John, is the largest and most protected bay on St. John. This bay supports the most extensive mangrove communities on St. John. Hurricane Hole, on the northern side of this bay, was chosen as a representative area to sample this type of habitat for fishery resources and determine its importance to the Virgin Islands Biosphere Reserve (Figure 1). Hurricane Hole is made up of a number of smaller bays (creeks) and one of these, Otter Creek, was chosen for this study. Otter Creek is a deep, narrow embayment with depths of up to 12m. The creek is mostly sand bottom in its outer portions with a bottom approaching mud in the innermost, lowest energy portion. These deeper parts of the creek do not appear to support any notable fish populations.

This creek is bordered nearly in its entirety by a narrow band of Red Mangrove (Rhizophora mangle). This species of mangrove supports itself in the water on proproots which can create a very structurally complex habitat in a very protected, low energy environment. Although this habitat is protected from wind, waves and current, water flow appears adequate to maintain the water at normal marine conditions. This combination of factors produces an ideal habitat for juvenile fish. They have adequate shelter, adequate food supply and an absence of most predators.

Twenty-one species of fish were observed here (Table 3). All of the demersal fin fish species were juveniles, although small adults were also observed for some species. The number of juveniles in this habitat points out the fact that this habitat is a very important nursery for many species of demersal fin fish.

This entire Hurricane Hole/Coral Bay nursery area may serve as a recruitment source for many of the reefs and nearshore communities along the south coast of St. John.

In addition to fin fish, juvenile lobster and conch were observed in this location. This habitat has been documented as a nursery area for juvenile lobsters (Olsen, et al, 1975). They report that all lobsters leave the mangroves by 80mm carapace length. Although not many lobsters were observed while sampling this location, it may be an important recruitment source for nearby parts of the Virgin Islands Biosphere Reserve. Juvenile conch are found in several protected embayments along the south shore of St. John. Due to the generally low mobility of this species, the juvenile conch found in this location are probably only serving as a recruitment source for the immediately adjacent mature conch habitats in Coral Bay.

### 3.5 Norman Island, British Virgin Islands

Norman Island (Figure 1) was selected due to its proximity to St. John and the possibility that nursery or reproductive habitats of significance exist there. The southwest and western end of the island is primarily composed of habitats with little potential for having any effect on the fishery resources of the Virgin Islands Biosphere Reserve. The coastline is mostly bordered by subtidal bedrock with nearshore grass beds or pavement and further offshore, bank gorgonion flats, grass or algae (Gladfelter, et al, 1985). These habitat types have all been shown to have little value as either nursery or reproductive habitats for commercial species (Boulon, 1985). Although the majority of habitats present have little or no potential for influencing the Virgin Islands Biosphere Reserve fisheries, two sites were sampled that could have potential if they were larger. These include an area of lower fore-reef north of Water Point and a small stand of shore mangroves at the head of the Bight.

### 3.5.1 North Water Point - Lower Fore-reef - Rf1

Starting just north of Water Point and extending along the north coast of Norman Island, nearly to the east end, is a narrow zone of lower fore-reef. This zone starts in shallow water (6m) as a relatively flat "coral garden" area with high percent cover (50-60%) by coral species. This zone then breaks at about 10m and drops fairly steeply to about 16m. The wall has lightly less coral cover (40-50%) and and is dominated by Montastrea annularis, Colphphyllia natans, Agaricia agaricites, and others.

While this appears as excellent reproductive habitat for many demersal fin fish species, the species found there are not very abundant or large, perhaps due to heavy fishing pressure as a number of traps were observed directly offshore from this coastal reef system. Fourteen species of commercially important fish were observed in this area (Table 3). The majority of these were seen as adults, but the number of individuals was low. Due to these conditions, the reproductive output from this habitat probably has no significant effect on fishery resources in the Virgin Islands Biosphere Reserve.

### 3.5.2 The Bight - Mangrove Shoreline - Sm

The Bight is a very large, deep bay bounded on the north by Water Point and on the south by Treasure Point. While the two points do contain some well developed fringing reefs, the majority of the bay is composed of sand, shallow bay pavement and some grass beds. At the very head of the bay is a small stand of Red Mangrove (Rhizophora mangle). This forms a small area of shore mangrove habitat with all the requirements for a nursery (see Section 3.4) except size. Fourteen species of commercially important fish were observed in this habitat (Table 3). Nearly all were observed as juveniles with some adults present.

This habitat does exist here as a nursery, however, due to its small size, it probably has no significant effect on the fishery resources in the Virgin Islands Biosphere Reserve. It may serve as a recruitment source for only immediately adjacent habitats on Norman Island.

### 3.6 Northeast St. John - Bank Pavement -Bp

Between St. John and Tortola there lies a body of water called the Narrows. This is the western end of the Sir Francis Drake Channel. This body of water is characterized by strong tidal currents and sometimes rough surface water. The portion of the Narrows sampled lies just northeast of Haulover Bay on St. John (Figure 1). There are two places in the Narrows where Tortola and St. John are connected by the 20 meter isobath. These two areas may very well act as migration avenues between the two islands. The water on either side of these "bridges" is as deep as 45m with barren sand bottom which is not an attractive habitat for fish.

The area sampled is the easternmost "bridge" and is primarily composed of bank pavement. It appears as a ridge with discontinuous raised areas of carbonate substrate. These raised areas are from several to 50m or more in diameter with sand separating them. The ridge drops off steeply on both sides from 18m to over 40m in depth.

These raised areas provide enough vertical relief to attract species of demersal fin fish and are undercut around their edges, providing good shelter for lobsters. Twelve species of commercially important fish were observed in this area along with many lobsters (Table 3). All species were present as adults with some juveniles. This area also has all the requirements for a reproductive habitat (adjacent deep water, good currents and shelter from predation), however, whether this has any effect on fishery resources within the Virgin Islands Biosphere Reserve is unknown (see Discussion).

The larger "bridge" to the west of the one sampled appears to be primarily composed of sand. It is much shallower (10m) and therefore current velocities are higher over it. This may lead to a greater degree of scouring action preventing the growth of major sessile invertebrates. This area is assumed to have an extremely depauperate resident fish fauna.

## 3.7 Great Thatch, British Virgin Islands

Great Thatch Island lies directly across the Narrows from Mary's Point, St. John (Figure 1). Due to its proximity it was sampled in various habitats to determine if any significant nursery or reproductive areas might exist that could possibly have an effect on the fishery resources of the Virgin Islands Biosphere Reserve. Great Thatch has a relatively narrow 20m shelf surrounding it with two bays on the south side facing St. John.

One of these bays is a shallow bay on the southwestern (A) side having a narrow fringing reef with a pavement area extending seaward out to grass and probably sand in the middle of the Narrows.

Further east on the south shore is a somewhat deeper bay (B). This bay has a rather well-developed fringing reef with a relatively deep back-reef lagoon. Just seaward of this reef is a narrow pavement zone followed by a steeply sloping, very well-developed fore-reef to a depth of 13m. All the zones in this bay appear to be very healthy and very well developed. The back-reef lagoon has many large heads of Montastrea annularis with sand-covered pavement between them. Many barracuda were observed in this lagoon.

Most of the rest of Great Thatch is subtidal bedrock near shore with a band of fore-reef pavement, a band of reef gorgonion flats and a narrow band of lower fore-reef as the shelf drops off to a sand or algal covered bottom at 25m. Habitat types selected to be sampled include two areas of upper fore-reef from both bays and a lower fore-reef located in the eastern bay.

### 3.7.1 Upper Fore-reef - Rfu

In all upper fore-reef areas sampled at Great Thatch Island, eleven species of commercially important fish were seen. This is low compared to combined upper fore-reef areas from St. John, but a much higher number of samples were obtained from St. John ( Refer to Boulon, 1985 ). Adults of all species were observed with a number of juveniles also present. None of the species observed were abundant.

The fish communities of upper fore-reef habitats around Great Thatch are of relatively low density (i.e., there is available habitat to support greater numbers of fish). This may be a result of over fishing whereas in the past, the fish may have been much more abundant. It can be assumed therefore, that this habitat at present has little or no effect on any fishery resources within the Virgin Islands Biosphere Reserve. The only possible interrelationship could be from fish that forage in the Narrows within the Virgin Islands Biosphere Reserve and return to the upper fore-reef areas along Great Thatch for daytime refuge.

### 3.7.2 Lower Fore-reef - Ff1

While the lower fore-reef areas in the eastern bay on Great Thatch Island appear to be very healthy and well developed, they do not appear to support very large populations of fish. Only six species of commercially important fish were observed. A low number of samples (two), may be partly responsible but very heavy fishing pressure may be the primary reason. Several blind (unbouyed) traps were observed in the area and a number of floats.

As such, it is doubtful whether this habitat would have any effect on the fishery resources of the Virgin Islands Biosphere Reserve. Any reproductive output from this habitat is unlikely to have any effect across the Narrows (see Disscussion).

## 3.8 Soper's Hole, Tortola, British Virgin Islands - Shoreline Mangrove - Sm

Soper's Hole, Tortola, is an embayment found between West End, Tortola, and Frenchman's Cay (Figure 1). The area between them at their closest points has, over time sedimented in and been colonized by mangroves. At present, the only remaining passage is a small mangrove-lined channel (approximately 20m wide) with a bridge along the edge of Frenchman's Cay. The area behind the mangroves on the Tortola side is being used as a spoil bank from the sand dredging operation in Soper's Hole. This sand is being used for construction both locally and in the U.S. Virgin Islands.

This area is undoubtedly quite affected by the sand dredging operation. The bottom in Soper's Hole is probably barren sand due to the dredging. When dredging is taking place, this whole area, including the mangrove-lined channel along Frenchman's Cay is probably subjected to heavy sedimentation from the runoff at the spoil bank. In spite of this, the mangrove channel still serves as a nursery habitat. Eleven species of commercially important fish were observed utilizing the mangrove roots as a protected, juvenile habitat (Table 3). While most species were present as juveniles, grey snapper, Nassau grouper and mullet were observed as larger, adult individuals. Barracuda were extremely abundant here in the 2cm to 15cm range (as many as ten seen together at a time). Schoolmaster were also very abundant.

While this habitat is relatively small in extent, it is possible that it may serve as a recruitment source for some part of the Virgin Islands Biosphere Reserve. This area is located on the northern end of the western "bridge" between St. John and Tortola. Recruits from the nursery habitat could conceivably migrate across the "bridge" and colonize areas along the adjacent north shore of St. John and Tortola. Recruits from the nursery habitat could conceivably migrate across the "bridge" and colonize areas along the adjacent north shore of St. John. This effect may be negligible due to the proximity of Mary's Point Creek on St. John. This is a much larger nursery habitat and may overshadow any contribution from Soper's Hole.

To the east of Soper's Hole, between Tortola and Frenchman's Cay, the coastline is primarily subtidal bedrock with grass beds seaward of it. The mangroves along this coastline do not have sufficiently submerged proproots to provide juvenile habitat. The road along the south coast of Tortla in this embayment has killed most of the mangroves.

# 4. DISCUSSION

It is unrealistic to consider the Virgin Islands Biosphere Reserve as an entity unto itself in terms of fishery stocks. Due to the planktonic life history phase of most reef fish larvae, and the migratory nature of the coastal pelagics, conch and lobster, the extent of ecological relationship with adjacent areas are undefinable. Although most pelagic larval forms may be long-lived, it has been observed that oceanic currents and counter currents coupled with vertical movements of young stages of fish may be the mechanism for maintenance of larval stocks in the vicinity of their parents (Richards, 1982).

In the Caribbean, where the island arc is directly in the path of the prevailing westerly current flow, a complex system of meanders and eddies of various scales has been detected (Molinari, et al, 1980), which can produce long residence times for some plankton. In a complex geographical distribution of islands such as the U.S. Virgin Islands and the British Virgin Islands, the current alterations can be even more complex. This produces a situation where no conclusive statements can be made concerning the distinctness of the genetic populations of fish found within the Virgin Islands Biosphere Reserve. The larvae recruiting into the local populations may or may not have originated from that population. Therefore, it is impossible to determine the effect that deepwater, reproductive habitats will have on the fishery resources of the Virgin Islands Biosphere Reserve.

Recruitment sources, or nursery areas, are much less complex when attempting to determine the interrelationship due to the more predictable movement patterns associated with the post-larval stage of most species. As demersal fin fish settle out of the plankton they generally move into protected, nearshore habitats to develop in relatively predator-free areas. The habitat predominately used as a nursery habitat is the mangrove embayment. In addition to demersal fin fish, lobster use this habitat as a nursery area for development. While several nurseries of this type do exist within the Virgin Islands Biosphere Reserve, it is unfortunate that the major nursery area on St. John, Coral Bay/Hurricane Hole is outside the Virgin Islands Biosphere (if the Virgin Islands Biosphere Reserve is considered to be wholly

composed of the National Park Service lands and water). In the development of the Virgin Islands Biosphere Reserve concept and its partition into use zones, this area should be strongly considered as a protected area, particularly the Hurricane Hole portion of Coral Bay, as the National Park Service does have control over some of the lands bordering these bodies of water.

Once demersal fin fish have moved out of the nursery habitat and are residing in a particular reef zone or system, there is probably little interaction with other reef systems. Some species engage in nocturnal foraging activities away from the reef and these migrations may carry them across Virgin Islands Biosphere Reserve boundaries. The effect of this could be to transport nutrients either into or out of the Virgin Islands Biosphere Reserve. Additionally, there may be some migration by certain species (yellowtail, queen triggerfish) from offshore bank or patch reefs to inshore reef areas.

Deepwater algal plains may serve as nursery areas and inshore recruitment sources for conch. It is in these deepwater algal plains where many of the most mature conch populations appear to reside and spawn (D. Ballantine, U.P.R., personal communication). Newly settled and growing conch may use this area due to an abundance of food and proper substrate for burying for protection or shell deposition (Randall, 1964). As they develop, they may move into nearshore grass beds where conditions are right for optimum growth. Juvenile fish of certain species have also been observed in these habitats, usually oriented to some bottom feature providing vertical relief such as a large sponge or piece of wreckage. Therefore, it may be that large portions of the offshore shelf areas around St. John are important recruitment sources for inshore conch and fish populations.

An important reproductive habitat for mature lobster appears to be the raised areas of bank pavement both north and south of St. John. These areas all lie outside of the National Park Service/Virgin Islands Biosphere Reserve boundaries, but must be considered within the context of the Virgin Islands Biosphere Reserve. These areas of bank pavement, the various bank patch reefs that probably occur frequently on the shelf region and the submerged shelf edge reefs (Colin, 1982), are

all important reproductive and refuge habitats for many species of demersal fin fish as well as lobsters.

The case for migratory coastal pelagic fish species is entirely different. They reproduce in the open ocean far from any hard bottom habitat, their eggs and larvae drift long distances away from land masses that might retain them nearby through current eddies and little is known of their development, metamorphosis and subsequent life histories. The majority of these species are highly migratory and may be affected greatly by general current flows in the Atlantic (Centaur, 1982). Whereas demersal fin fish can be defined in terms of a local management unit, the accepted management unit for the coastal migratory pelagics encompasses the entire Caribbean and parts of the Atlantic. This makes it impossible to attempt to quantify the ecological relationship between the Virgin Islands Biosphere Reserve and the areas adjacent to it for coastal migratory pelagics.

As indicated in the above discussion, it appears to be very important that the Virgin Islands Biosphere Reserve be expanded beyond the boundaries of the National Park Service on St. John. A number of important fishery habitats lie outside of these boundaries at the present time. It seems apparent that these boundaries need not be extended to British Virgin Island nearshore habitats, however, their offshore habitats may influence nearshore fisheries of the Virgin Islands Biosphere Reserve and should be considered for inclusion.

It is entirely artificial to attempt to separate all of these islands in terms of fishery stocks, particularly regarding coastal migratory pelagics. There is a definite need to obtain more in-depth information on many of the offshore reproductive habitats in terms of exactly what species are utilizing them and their value to these species. Nursery habitats are in critical need of protection from development. Their value to the fisheries of the region are immeasurable. Management of these areas and their inclusion into the Virgin Islands Biosphere Reserve as a first step towards protecting them is a topic for serious consideration.

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APPENDIX I

Refer to pages 68 and 69 of Appendix I of Report No. 8 (Maps 16 and 17).