SPECIAL RE PORT

STUDY OF THE FISHERIES POTENTIAL

OF THE

VIRGIN ISLANDS

Contribution Number 1
Virgin Islands Ecological Research Station
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PRE FACE

In August of 1965, the Caribbean Research Institute (CRI) of the College of the Virgin Islands (CVI) undertook concurrently the establishment of the Virgin Islands Ecological Research Station (VIERS) and a fishery project to be conducted through the facilities offered by the Station. Their project was supported by the U. S. Bureau of Sport Fisheries and Wildlife (BSFW) with funds coming from D-J project F-4-R. The first building to be erected at the site of the Research Station (Lameshur Bay, St. John) was a fisheries laboratory constructed with funds from the Accelerated Public Works Program. Before this construction, VIERS used a leased facility at Chocolate Hole, St. John.

In February 1966, the U. S. Bureau of Comm ercial Fisheries (BC F) through the PL-88-309 program agreed to enter jointly with the Bureau of Sport Fisheries and Wildlife into a project entitled "Study of the Fishery Potential of the Virgin Islands." This combined fisheries research program has been designated F-4-R by the BSFW and 2-33-R by the BCF. Matching funds were made available by Virgin Islands legislative action with funds allotted to the College of the Virgin Islands by the Office of the Governor.

Since the inception of the program in 1965, many people have participated and contributed in one way or another to the study. It is impossible to thank all those who did contribute but certainly those listed below deserve special mention: Mr. D. Allen, Secretary to the Director, Virgin Islands Ecological Research Station; Mr. J. Brown, Superintendent, Virgin Islands National Park; Miss M. Bryant, Director of the Budget, Government of the U. S. Virgin Islands; Mrs. N. Carlson, Project Coordinator, Caribbean Research Institute; Mrs. A. Dammann, Secretary to the Director, Caribbean Research Institute; Mr. M. De Castro, Director of the Budget, Government of the U. S. Virgin Islands; Mr. C. Evans, Fisheries Technician; Mr. T. Finucan, Advisor to the President, College of the Virgin Islands and Interim Director, Caribbean Research Institute; Mr. F. Givens, Superintendent, Virgin Islands National Park; Mr. C. Harrigan, Caretaker, Virgin Islands Ecological Research Station; Mr. I. Koblick, Fisheries Technician, and Coordinator of Field Studies, Virgin Islands Ecological Research Station; Miss J. Lasko, bio-assay of Uca pugnax; Mr. R. McClendon, Fisheries Biologist; Mr. R. Paiewonsky, Governor of the U. S. Virgin Islands; Mr. P. Winkler, Fisheries Biologist; Mr. J. Yntema, Boat Supervisor, Virgin Islands Ecological Research Station; and Miss S. Yntema, Research Assistant, Virgin Islands Ecological Research Station; Dr. E. Towle, Director, Caribbean Research Institute.

In addition to those persons listed above, Captains Jerry Black, Jimmy Loveland, Johnny Harms and Tom Gifford have contributed many data on catch effort and localities, in addition to many fish specimens, to the project. Captain Harms' carefully maintained records have been a valuable contribution to our knowledge of the Sport Fishery of the islands.

Mr. Koblick, Mr. Swingle, Mr. Yntema and the Project Leader have assumed the responsibility for the major part of the field work and/or writing of this report. Mr. Allen and Miss Yntema have done the typing and reproduction.

To all these people and the many others not mentioned, but who have contributed in one way or another, go our thanks and appreciation.

Arthur E. Dammann
Project Leader
and
Director,
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August 31, 1969

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INTRODUCTION

The objectives of this report are to provide a concise review of our previous knowledge of the fish and fisheries of the Virgin Islands, to contribute to this knowledge and to make recommendations concerning the subject. It is hoped that such an approach will prove of value not only to fisheries workers and fishermen, but also to government officials and administrators in many departments, as well as to interested citizens.

Bayer (1968) has provided a resume of research and exploration in the Caribbean Sea and adjacent waters. According to him, meaningful written records started with Columbus' landfall, although there were certainly pre-Columbian Europeans in the area. The following chronological summarization is compiled from the paper by Bayer, and is meant to provide a brief orientation with respect to the marine research in the Caribbean which has contributed to our knowledge of the fish and fisheries of the Virgin Islands. Complete references will be found in Bayer's paper.

Gonzalo Ferdinand Oviedo published "Natural History of the West Indies" (1526) and "General and Natural History of the Indies" (1535, 1537). These works include an extensive section on fishing and fishes. John White on the ship "Tiger" described St. Croix and Puerto Rico (1585), illustrating many fishes and crustaceans. Clusius (1605), Cerutus (1622), Jonston (1650), Worm (1655) and Olearius (1674) all described and illustrated marine organisms from the Caribbean. Mark Catesby in "The Natural History of Carolina, Florida, and the Bahama Islands" (1731-1734) illustrated 44 species of West Indian fishes along with many marine invertebrates.

Many oceanographic cruises have contributed data on fisheries and the oceanographic parameters associated with fish and fisheries. The following list of the ships involved in these cruises is extracted from Bayer.

HMS Challenger (1872-1876) -- Eight stations in the Caribbean
U. S. Coast and Geodetic Survey steamer "Blake" (1879-1880) -- 300 stations in the Caribbean
U. S. Fish Commission steamer "Albatross" (1884-1919) -- 955 stations in the Caribbean
U.S. Fish Commission steamer "Fish Hawk" (1898) was sent to Puerto Rico and 20 special reports resulted
Johnson-Smithsonian Deep-Sea Expedition yacht "Caroline" (1933) went to the Puerto Rico Deep

U. S. Fish and Wildlife Service Vessels have included:

R/V Oregon (1950–present) --1,461 Caribbean stations, 3,914 Gulf of Mexico stations, 1,860 on the Atlantic Coast of Florida, 394 off South America

M/V Silver Bay -- 433 Caribbean stations

M/V Combat -- 80 Caribbean stations

Since 1900 the number of ships and institutions working in the Caribbean area has increased greatly; it is estimated by Bayer that during the past 100 years about 10,000 biological stations have been occupied and that 3,446 of these were within the Caribbean proper.

An enormous amount of effort has been devoted by individuals associated with many institutions and organizations from the United States and nearly all the Caribbean countries, as well as Europe and Asia. These efforts are increasing at such an accelerated rate at the present time that it is impossible to correlate all the data and present a unified and coherent picture of the Caribbean Sea as a fisheries potential. This was made abundantly clear at the Symposium on Investigations and Resources of the Caribbean Sea and adjacent Regions Preparatory to CICAR (Cooperative Investigation in the Caribbean and Adjacent Regions). These meetings, organized through the joint efforts of FAO (Food and Agriculture Organization of the United Nations) and UNESCO (United Nations Educational, Scientific and Cultural Organization), were held in Willemstad, Curacao in November 1968. The Project Leader attended and contributed to these meetings. More than 150 scientists presented papers at these meetings and the areas of discussion included Physical Oceanography (40 papers), Marine Geology (17 papers), Marine Biology (29 papers), and Fishery Resources (65 papers). Many of these papers will be cited throughout this report.

It would seem from the above outline that the Caribbean must be a very well known area and that little work remains to be done. Nothing could be further from the truth. In the area of Physical Oceanography, only the most general distribution patterns for such things as currents, temperatures and salinities are known, and even these patterns are variable enough to provide grounds for disagreement among knowledgeable people. The contributions of these general patterns to the specific ones occuring in very small areas along a coast line are, in general, unknown. Marine geologists debate the origin, age and configuration of the sea floor as well as the stability and ages of the land masses forming the boundaries of the Caribbean Sea. Marine biologists still lack even basic taxonomic inventories in each group of organisms, and virtually nothing is known of the biology of the species which have been described. In fishery resources the same conditions prevail. Number of species, their

CHAPTER I

THE PHYSICAL ENVIRONMENT

distributions, population dynamics, general biology, consumer value, methods of harvesting and marketing, and a host of related factors are, in general, poorly understood or completely unknown.

With respect to the marine biology and the fish and fisheries of the island arc forming the northern and eastern boundaries of the Caribbean Sea, perhaps even less is known than for the entire area, or for the mainlands on the south and west. The relatively few general reports and a review of current efforts will be cited or provided in the appropriate sections of this report.

References specifically relating to the Virgin Islands are scant indeed. Some of the data of most general interest and relevance are to be found in the works of Fiedler and Jarvis (1932); Idyll (1959); Anon., in "Report of Meeting of Caribbean Fishery Officers in Puerto Rico" (1961); Halstead (1965), (1967); Randall (1958), (1961), (1968); Nichols (1929), (1930); Bohlke and Chaplin (1968); and Evermann et al (1902).

We wish to stress the fact that because fish and other organisms do not recognize political boundaries, a fishery in the American Virgin Islands is not, and cannot be, an independent and isolated entity based upon artificial boundaries. We must have the information provided by studies of the entire Caribbean and tropical Atlantic regions at our disposal. Any long-range, sustained effort at harvesting, managing and conserving the resource can only be fortuitously successful when it is based on incomplete knowledge of the resource and the natural factors which regulate it. The history of fishing is replete with the tragic blunders of proceeding without knowledge (Russell, 1942). Granting the fact that our knowledge can never be complete, it is still imperative that we know as much as possible about any resource that we wish to manage over an indefinite time schedule. In the case of fisheries we first of all must know what species are available in an area. Because of its ultimate importance in understanding population dynamics and other related biological factors, this means that good and accurate taxonomic and systematic biology must precede all other studies. Every ichthyologist can cite numerous examples of two or more species being confused as one (Randall, 1961) -- or, quite the opposite, one species being considered as several because of ontogenetic or sexual variation (Randall and Caldwell, 1966). Failure to recognize these cases can make meaningful management an impossibility.

In addition to knowing what animals one has that might be harvested, one must know where they come from, what their total range is, how many of them are available, at what rate they reproduce, and, especially, their relationship to their total environment. The last item tells us what factors are necessary for their survival, and includes such things as behavior, food, shelter, enemies, water quality, habitat preference, adaptability to changing conditions, and the like. With enough information available on these topics it becomes possible to devise methods for maintaining a maximum sustained yield. It may even become possible to increase the number of some kinds of animals that may be harvested.

During the course of this study, project personnel visited all the Virgin Islands (American and British) at least once by boat, and, in addition to landing, observed the entire shoreline of each from the boat. Many airplane flights were made over all the islands in complex patterns designed to provide personnel with an understanding of distances, reefs, bays and shoal localities, and insular relationships and topography.

Many hours were spent with SCUBA and snorkel. Trolling was carried on when possible, and water temperature, salinity and transparency were observed and recorded at many places and on many occasions.

Stations were set up for repetitive sampling of temperature, salinity and transparency, and more than 100 nautical miles of ocean bottom were observed on transect courses run by glass-bottomed vessels.

Bottom dredges, otter trawls, hand nets, plankton nets, hook and line, fish traps and rotenone were employed for obtaining specimens and quantitative data about populations. In one instance an entire reef was enclosed by netting and studied quantitatively. C^{14} was used in productivity measurements.

Nansen bottles, Niskin current recorders, sampling bags, Secci discs, and an electronic temperature/salinity/conductivity meter were used to measure water quality.

The collection stations and techniques employed during the different studies are set forth in the relevant chapters which follow.

CHAPTER I: THE PHYSICAL ENVIRONMENT

The three large-scale features of the physical environment affecting fish of the American Virgin Islands are (1) the geographic location, (2) the fact that while St. Thomas, St. John and their associated smaller islands and cays rest on the same "continental" shelf with Puerto Rico and the British Virgin Islands, St. Croix is isolated from all other islands by deep trenches, and (3) the size and nature of the land masses. These three factors have an overriding influence on all the subsidiary environmental patterns.

The location of the Virgin Islands, at approximately 65 degrees west and 18 degrees north, is well below the tropic of Cancer and hence in the true tropics, as opposed to Florida and many of the Bahama Islands, which are often spoken of and treated as being tropical. This location has profound effects on such things as water temperature, insolation, number of daylight hours, and length and intensity of seasons. It also places the Virgin Islands in the path of the trade winds, which interact with the surface of the sea and affect wave action, turbidity, storm patterns, rainfall, and currents. All these factors become a part of the marine environment. The location is also one which is in the path of severe tropical storms which occasionally alter the marine environment by destroying reefs and shorelines, and by depositing vast quantities of fresh water in a short period of time which in turn carry many tons of silt from the land masses into the sea. The wave action from these storms also completely disrupts the bottom configuration and sedimentary deposits in shallow bays and inlets. Finally, the location places the Virgin Islands in the pathway of the North Equatorial current which flows westward from Africa. This influences not only water quality and local currents but the seasonality and distribution of many marine organisms, including fish, as well.

The geological shelf from which rise the islands of Puerto Rico and all the Virgin Islands except St. Croix is, in essence, a small "continental" mass surrounded by deep water. The Puerto Rican Trench to the north is the deepest spot in the Atlantic Ocean (27,498 feet), and is, in fact, the third deepest spot known in all the oceans. This shelf is an underwater plateau with its top lying, for the most part, 200-300 feet below the surface and falling off abruptly around the periphery into very deep water. It is rather level and smooth except for the island masses which rise above the surface and the underwater coral reefs and rock masses which are found in abundance over the entire 2,000 square miles of shallow shelf, about 300 miles of shelf edge and about 500 miles of shoreline.

According to Donnelly and Whetten (1968), Donnelly (1966) and Weyl (1966), the shelf and the islands are Late Cretaceous - Early Tertiary in origin, but are also still in the process of formation. They are also, with respect to animal distribution, "oceanic" islands and hence have probably never been connected with the true continental mass. As we shall see later, these two factors have a very definite effect on the kinds and numbers of fish and other organisms found here.

St. Thomas and the other Virgin Islands are separated from the islands of Puerto Rico by the Puerto Rico Graben. St. Croix is separated from all the other Virgin Islands by the Anegada Trough, and is ringed by a very narrow underwater shelf. The various islands differ greatly in size and topography. In general, the relationship that these features have to the marine environment is one which involves rainfall and runoff of surface and subsurface water. Of course, the increased amount of shoreline provided by a large island or one of highly irregular shape also becomes important to the marine environment, since shoreline features provide increased cover, food and living space for many organisms.

As a rule the larger an island is, and the higher it rises above sea level, the more rainfall it receives. If we disregard the effects that man has on the landscape, these larger islands will then have a greater potential for permanent streams and thus be able to provide true estuarine environments with their lowered salinities and high nutrient contents. Such estuaries enormously increase the fisheries potential of an area. Among the islands under discussion, only Puerto Rico itself provides such conditions; at the present time it is the only island in the area with permanent streams which discharge enough water to influence the marine environment. Deforestation, cultivation and erosion have long ago destroyed any permanent streams that may have existed on the smaller islands in Pre-Columbian times.

Since the scope of this study did not include the Puerto Rican islands per se, we will turn our attention exclusively to some of the small-scale features of the physical environment provided for fish by the Virgin Islands themselves.

Currents

As the North Equatorial and Caribbean currents sweep in across the Atlantic and encounter the Lesser Antilles island arc there is an upwelling of deep water which in some places flows across the shallow shelf area and through the passages between islands. The presence or absence of upwelling and the contribution (or lack of it) of deep Atlantic water to the water of the Caribbean Sea have been discussed by Fukuoka (1968), Goulet (1968), Perlroth (1968), Giese (1968), Brucks (1968), Worthington (1968), and Wood (1968).

The general effect of upwelling where it occurs is one of supplying additional nutrients to the shallow waters into which the upwelling occurs. This, coupled with the fact that the edge of the shelf lies within the photic zone, accounts for the well-developed reefs in this area. The water from the open Atlantic is soon modified as it crosses the shelf and the vast quantities of this water are compressed and forced under great stress through the narrow passages between islands. Here the east-west pattern is disrupted into many smaller currents and counter-currents. Some of these reach great velocity during periods of tidal change, and strong tidal rips occur in these passages. The patterns between the islands are highly variable on a day by day basis as well as on a seasonal basis. Perlroth (1968) has shown cyclonic and anti-cyclonic current shifts adjacent to the east-west orientation of the Caribbean Current. In August this brings the main Atlantic water mass into contact with the islands from a southeastern angle, while during January the water comes from due east (Chart 1). No analysis has *been* made of the causes for the daily pattern shifts of the inter-island currents but presumably they are due to a combination of wind effect and tidal volume. While it has been impossible during the course of this study to obtain many quantitative data on inshore currents around the islands, it has been possible to plot some of these data qualitatively and in a few instances to estimate current speed. Chart 1 illustrates a few of these inshore currents, and Charts 2 and 3 indicate magnitudes of two representative situations.

Currents are important in an overall understanding of fish distribution and movement for at least two reasons. Pelagic fish respond to currents and the temperature and salinity of the water involved in them, as opposed to the more quiet waters outside their influence (Roule, 1933). The currents also carry nutrients which aid in reef development and growth, which in turn are important to the reef-dwelling fish.

Our current measurements were made by measuring the rate of dye dispersal or float travel, or by means of a calibrated Niskin recorder.

Tides

Along mainland coasts, and especially at the upper ends of long and narrow gulfs and bays such as the Bay of Fundy and the Gulf of California, tidal fluctuations reach phenomenal proportions. Such a situation creates vast intertidal zones which contribute to the variety of habitats available to fish and their associated organisms. Fishermen live by the tide tables and know that their chances of success are heightened considerably if they fish for certain species on the incoming, outgoing, or slack tide. Many kinds of shell fish are only harvested at low tide when huge areas of land are laid bare or covered by very shallow water.

In areas of small islands where the land mass is not extensive enough to trap the tidal influx, this situation does not occur. The water flows around the ends of the islands and the result is a tidal fluctuation of only a few inches per day, but the rhythms may be complex (Graph 1). If the land mass enters the water steeply, as is usually the case with the Virgin Islands, there are few flats to be uncovered by this diminished fluctuation. The result is that the intertidal areas are much reduced in size and in many cases become vertical surfaces on rock facings. This fact makes the few shallow water, lagoon-type, intertidal areas in the Virgin Islands of great value as a natural resource from the standpoint of fisheries.

Unfortunately, the value of these shallow water areas as natural resources is largely being ignored in the Virgin Islands just as it has been for many areas along mainland coasts. Dredging and filling operations have destroyed many of these sites. One of the few remaining lagoons in the American Virgin Islands -- the area known as Jersey Bay and Mangrove Lagoon, situated near the eastern end of St. Thomas -- has received special attention from our efforts as well as the efforts of other investigators. McNulty, Robertson and Horton (1968) and Tabb and Michel (1968) have worked here, because this area too is slated for destruction or drastic change to accommodate a jet airport at the site.

An anomolous situation is the creation of additional lagoon areas in the islands by opening many of the "salt ponds" to the sea. These ponds are normally cut off from the sea by storm-tossed coral rubble berms. Their depth, temperature, salinity and biotas are highly variable and dependent upon the amount of rainfall, as long as the berm is intact. Under these closed conditions they are used as refuges and feeding and nesting areas by shore birds and ducks but are unavailable to fish. When the berm is naturally opened by a storm, or artificially opened by machinery, the biota and physical factors are so radically changed by the admission of sea water that the pond becomes available to marine fish but unavailable to the former bird populations. From the standpoint of fisheries then, additional valuable shallow-water habitat has been created by these opened ponds which are now under the influence of the tides. When a pond is filled, however, it is no longer available to either fish or birds and is thus completely lost as a natural resource.

Temperature

As given by Perlroth (1968), open ocean sea surface temperature in the area of the Virgin Islands for the month of August lies between 27.5 degrees C and 28.0 degrees C (our data fit this well, Chart 4), with the top of the thermocline at 50 meters. January temperatures fall between 25.5 degrees C and 26.0 degrees C (Chart 5), with the top of the thermocline between 75 and 100 meters.

Over the shallower areas of the shelf, and in the bays and other shallow and protected areas such as tide pools, lagoons and opened ponds, the temperature variation is much greater than this with the uppermost layers warming and cooling rapidly under the influence of the sun (Table 1). The maximum temperature recorded in such spots during this study was 38.2 degrees C (Chart 4), and several species of fish were always present. The minimum temperature during the same period was 24.0 degrees C (Chart 5). References to the relationship of temperature and fishes are numerous (Svedrup et al. ,1942). Many studies concern upper and lower tolerances in terms of lethal effects. In fresh water fishes, or in the case of fishes trapped in small bodies of water, these relationships may be critical in terms of the individual, and even of populations, under extreme or special conditions. In temperate zones the range of water temperature during the course of a year is great and has a very definite effect on the distribution and availability of individual species which are often decidedly seasonal in occurrence and/or behavior.

In tropical regions the range of variation in water temperature is much less (note Table 1 and Charts 4 and 5), and many demersel fish seem to be little affected by seasonal variations. However, pelagic fishes range widely throughout the oceans and encounter seasonal changes in their travels. They frequently migrate in a regular pattern from one area to another (Roule, 1933). Whether or not this is in response to water temperature or some other factor is difficult to determine. It is sometimes possible to correlate the distribution of certain species with given temperature gradients. Thus, from the practical point of view of the fisherman, it is of little importance whether or not the temperature per se is the controlling factor as long as he can predict the availability of a species whenever certain temperatures are encountered within its geographical range. August and January temperatures are plotted against catches of pelagic game fish which show three basic kinds of seasonal distribution in Graphs 1 - 5.

In this project, temperatures were taken with hand-held mercury thermometers or with an electronic probe.

<u>Salinity</u>

During the course of this study salinity measurements were originally taken with glass salinometers manufactured by Gem Instrument Company. These proved to be too easily broken and replacement was always a problem. During the last few months of the project an electronic salinity/temperature/conductivity meter was obtained and proved much more satisfactory.

Svedrup et al. (1942) states that "As the range [salinity] in open oceans is rather small, it is sometimes convenient to use a salinity of 35 ppt (parts per thousand) as an average for all oceans." Many random measurements of offshore water and open near-shore water indicated that for the purposes of our work this was true for the Virgin Islands.

Remarkable deviations from this figure occurred only in quiet shallow back waters where evaporation was high. Results of a detailed study of one such area, the Mangrove Lagoon on St. Thomas, are presented in Chart 6. It can be seen that the salinity is highest in the head of each arm where circulation is least. Measurements were taken just below the surface in each case. The highest reading of 36.4 ppt occurred in water 14 inches deep. The second highest reading of 36.3 ppt was in water just over 4 feet deep. During the spring of 1969 after the conclusion of the measurements recorded here, and following an accumulation of more than 10 inches of rain, this whole lagoon was fresh to a depth of approximately 32 inches, where a distinct interface occurred. This fresh water killed virtually all of the marine phytoplankton and changed the color of the lagoon from green to brown. This condition persisted at the surface for more than 60 days. It was not possible to undertake biological studies of this rather infrequent phenomenon.

It must be presumed that most of the shallows in the islands present a picture somewhat like the above, and that the normal salinity gradients, with occasional drastic changes, play an important role in controlling the life histories of the organisms inhabiting such areas. It is a well-known fact that variations in salinity are necessary to the development of many fishes and crustaceans. The lack of estuarine areas with their lowered salinity (the opposite of our lagoon) precludes the presence of large populations of peneiid shrimp as found along the coast in the Gulf of Mexico.

The Substrate

During the course of this study the substrate was sampled by means of a 4-ounce Gemw are Mudsnapper, a dredge made from 8" well casing, or, in most cases, by direct visual observation using a glass bucket, snorkel and face mask or SCUBA.

In addition, more than 100 nautical miles of transects were made with a barge having a 3' x 8' glass-bottomed well which housed one or two observers. It was possible to obtain a quantification of sorts by using the following method:

A predetermined transect line was run at a constant rate of speed. At the beginning of the run, a recording fathometer and a stop watch were started simultaneously. The observers recorded their observations on a tape recorder. Periodically they recorded depths from the fathometer chart and times from the watch. At designated instants a worker on deck obtained a shoreline "fix" which was written down, along with elapsed time, on the nautical chart which also indicated the course of the transect. At spots of particular interest, the observers called for a "mark" and a small line with a weight at one end and a float at the other was dropped overboard. At the conclusion of the transects, divers could return to these spots for detailed observations or collections from which identifications could be made. Later in the laboratory these parameters were all correlated to provide a composite picture of the substrate with notes about fish and other organisms superimposed. The running commentary was typed verbatim from the tapes. Chart 10 indicates the location of transect lines.

Some general remarks and estimates about the physical substrate follow:

The shallow bays which have coral sand beaches or mixed sand and cobblestone or rubble at their head, have coral sand bottoms which are usually covered with turtle grass and eel grass. There is usually less than 10% of the substrate which supports coral or exposed rock in the center of such bays. However, there are either living or dead fringing reefs on either side of the mouth of such bays, or patch reefs across the mouth. These reefs are, of course, the source of the sand for the beach (Randall, 1963).

Rocky shorelines, including purely cobblestone beaches, usually have rocky offshore bottoms with not more than 25% sand intermixed. This sand originates from the coral growth covering the rocks or forming isolated coral "heads." In these cases the sand is usually unconsolidated and does not support vegetation.

There is always a zone of unconsolidated sand which separates living reef from turtle grass beds. This is maintained by the grazing of reef fish (Randall, 1965) and averages thirty feet in width.

Immediately in front of mangrove shorelines the substrate is almost always mud. It may or may not support aquatic vegetation such as turtle grass intermixed with coralline algae and small patches of Porites (dead man's fingers) coral.

These conditions are well illustrated on the south side of the islands of Anegada, Buck, and St. Croix. Here there are patches of mangrove usually associated with small muddy areas. Out from these extend many square miles of shallow coral sand bottom dotted with "heads" of living coral. Close to shore the coral makes up 10-30% of the substrate and the sand is white and often unconsolidated between the heads. Farther out, turtle grass and several algae cover the sand and the heads become fringing reefs.

At the edge of the 50 or 100 fathom (almost synonymous) drop off, dredged

samples and direct observation by SCUBA on raised ridges indicate that the bottom is mostly dead coral rubble, except where the drop off is near an island, as along the northern shore of Anegada and St. Croix, where there are well-developed reefs.

Many transects with recording fathometer and dredge samples indicate that about 50% of the shelf is composed of heads and patches of living coral interspersed with dead coral rubble. The other 50% is rather smooth and composed of intermixed sand and coral rubble.

In the preceding paragraphs it has been impossible to entirely separate the physical substrate from the biological one since coral is at once living on the surface and dead beneath, while the condition of small particles is determined by whether or not they support vegetative growth. Geologists are quite as interested in coral reefs and the sand they produce as are biologists (see next section).

CHAPTER II

THE BIOLOGICAL ENVIRONMENT

CHAPTER II: THE BIOLOGICAL ENVIRONMENT

Just as the physical environment involves both the water column and the substrate, so does the biological environment. The water column supports the planktonic community, which is the basis of the food chain upon which most fish depend in oceanic waters.

While it is true that photosynthetic organisms which are attached do trap sunlight and produce sugars which enter the food chain, they probably play a lesser role in productivity in most areas than do the microscopic floating algae.

Phytopla.nkton populations in the Caribbean are derived from the North Equatorial Current and their composition and numbers are influenced in this area by the presence of large quantities of the brown alga Sargas sum. The alga supports a large community of epiphytic microalgae which become detached and form part of the phytoplankton. The greatest populations of phytoplankton are present in the region of the thermocline, and/or close to the 1% level of surface illumination (Wood, 1968).

In this area this should put them at about the 150 foot depth in August and between 225 feet and 300 feet during January (Perlroth, 1968). Our few efforts to collect phytoplankton near the surface in inshore waters certainly reflect this since volumes were always very low except in areas with an obvious "bloom."

Margalef (1968) makes clear that the highest nutrient enrichment areas are near continental or peripheral areas, and around islands. His data show cell counts ranging from 20-200/ml. These are composed of more than 450 "species" with the nannoplankton largely unknown. Primary productivity as estimated by C^{14} uptake ranges from 400 g C/m^2 in the highly fertilized areas, to 100 g C/m^2 in some bays and mangrove areas, to 20-100 g C/m^2 in the poor areas of the Central Caribbean.

Tables 2 - 5 review some preliminary data obtained by project personnel which, in general, agree with Margalef's figures on productivity. Our experiments show little of the "shade" adaptation postulated by Wood (1968). Of course, it could very well be that the species associated with surface waters are not strongly shade-adapted.

Many other productivity experiments were run from water samples around the Virgin Islands and these results will be published separately by Burkholder.

Primary productivity is a valuable index to the ability of many areas to produce and support fish. This is true not only because the phytoplankton itself is utilized as food by small fishes, but also because the zooplankton populations are also highest where the phytoplankton reaches greatest abundance, and the zooplankton is certainly primary fish food (Wood, 1968), (Margalef, 1968), (Steven, 1968).

Owre (1968) states that the eastern Caribbean serves as a zooplanktonic nursery area and that the greatest diversity of species occurs in deep waters, whereas in the upper 100 m there are great numbers of relatively few species. The latter statement has certainly been true in some of the plankton samples taken by project personnel. On several occasions salps and ctenophores literally filled the nets.

Our very small zooplankton collection contains siphonophores, heteropods, copepods, euphausiids, salps, cheatognaths, ostracods, cladocerans and amphipods, but they are still waiting for further identification by specialists. As an indication of the enormity of this task, Owre (1968) accounts for 302 species of copepods alone from the area, of which 28 are newly described calanoids, and 58 are previously unreported for the area. Hammer (1968) claims 790 species of benthic algae are known in the Caribbean. Of these, 28% are said to be endemic. It is not certain how many species are planktonic but the number is certainly high according to Margalef (1968). Detailed investigations of this magnitude were far beyond the scope of the present study. Wimpenny (1966) includes 46 pages of illustrations plus some 50 figures as an aid in identifying major planktonic groups; we have relied heavily on this work.

In Chapter I we mentioned briefly the relationship of stony corals and turtle grass to the physical and biological environments. Since both groups are living organisms, they form a major part of the biological environment for fish, providing food and cover for both the fish and literally thousands of other organisms which are associated with them. Along with the soft corals, sponges, sea urchins, and a few molluscs, they form the dominant, or obvious, members of the reef community other than the fishes themselves. We have estimated that at least 50% of the shelf area provides a reef or reef-like environment for fish.

This reef, or reef-like, environment assumes many shapes and many combinations of species. While it is possible to describe some of the reef forms in such common terms as encrusting, or staghorn, or brain, or gorgonian forest, etc., it has been impossible to undertake a detailed study of more than a very small sample of living reefs during the course of this project.

In the next chapter we will discuss the population of fishes inhabiting a small shallow reef, but at the present time the reef itself is of interest. The reef under study, located in Chocolate Hole, St. John, measured 120 feet long and 75 feet wide by 30 feet deep. Line transects were stretched across the reef in such a manner that they provided equivalents of parallel transects no greater than 1 meter apart. Sessile organisms touched by the line were counted, measured and identified.

Table 6 tabulates these samples by percentages of cover. In this particular instance we see that the surface of the "reef" was composed of 43% non-living material and 57% living organisms. The latter included 11 species of soft coral, at least 4 species of sponges and a few organisms such as sea squirts, tube worms, etc. There are, of course, many cryptic forms not included. There are many areas similar to this in the Virgin Islands, but it is by no means "typical" and should not be used as a model since other "reefs" are vastly different in composition (Stoeckle et al., 1968). It will be noted that the long-spined sea urchin Diadema attained a rather substantial population size on this particular reef. Its numbers drop dramatically once one leaves the reef and enters the adjoining turtle grass area. Randall et al. (1964) records $13.4/m^2$ in the Virgin Islands. They considered this to be high but it is only a fraction of our count of approximately $65/m^2$.

Kumpf and Randall (1959) charted the marine environments of the island of St. John from the shoreline to the ten-fathom line. This work was done by having the observer towed on a sled behind a small boat. The publication includes a map of the inshore bottom around the island.

Museum collections of sponges (80 sp.), corals (40 sp.), molluscs (800 sp.) and a few other invertebrates have been made, sent away to experts for verification of identities, catalogued and stored in glass containers and steel museum cases in the laboratory at Lameshur Bay.

During the course of this project another reef complex was analyzed in detail by Stoeckle et al. (1968)in cooperation with project personnel and the Virgin Islands Ecological Research Station. This is in the form of an unpublished manuscript, parts of which are included, verbatim, on the following pages.

THE MARY CREEK REEF COMPLEX, St. John, U.S. Virgin Islands

Abstract

A fringing reef complex on the north shore of St. John, U.S. Virgin Islands, was studied in the Mary Creek area. Six ecological and depositional zones were defined and mapped within the reef complex: 1) pro-reef sand; 2) living reef; 3) coral rubble; 4) grass-sand-rubble; 5) grass-sand; 6) sand. The complex contains three reef patches separated by two deeper channels. The framework is

composed of three main types of organic accumulation: 1) rigid frames (massive types of coral - Montastrea, Diploria, Acropora); 2) non-rigid frames (delicate corals - Porites,Octacorals, Lithothamnium); and 3) skeletal sediment. The rigid frames thrive under exposure to rough water conditions accounting for the presence of the reef and creating many protected environmental niches exploited by the non-rigid frame organisms. Encrusting coralline algae play a dominant role in the reef complex by welding and cementing pieces of loose debris to the reef frame. Forces of growth balance the forces of destruction, but the latter are more apparent. The outward growth of the reef is dependent on the extension of frame building activity on the unconsolidated pro-reef sand. They create the foundation of reef rock on which secondary frame builders can establish themselves followed by the non-rigid frames. The outward growth toward the wind and waves as well as the presence of inlet channels reflects the need for a maximum concentration of oxygen and nutrients in the water engulfing the reef.

Introduction

A reef can be considered a dynamic, living organism. It results from a vastly complex association of living things and their skeletons, all associated together in an ecological and sedimentationed balance, each plant and animal contributing to the life and growth of the reef as a whole and to the delicate balance maintained between constructive and destructive forces. Each *reef* complex has its own distinctive ecological and depositional zones, which taken as a whole illustrate the interaction and balance which exists between the zones.

A fringing reef complex on the North shore of St. John, U. S. Virgin Islands, was studied in the Mary Creek area (Figure 1). Six ecological and depositional zones can be defined within the reef complex, although the zone boundaries are gradational and often hard to define. These six zones are: 1) Pro-reef sand, 2) living reef, 3) coral rubble, 4) grass-sand-rubble, 5) grass-sand and 6) sand respectively.

The reef itself is built up from a sandy sea floor and faces the Northeast and the prevailing winds. The three reef patches of the complex are sectioned off by deeper channels of little active coral growth. The present balanced situation between the active living coral on the fore-reef and the dead or dying coral on the back reef and in the rubble zone, leaves open the possibility of many questions concerning the reef's history. What was its origin? By what process has growth occurred? Will it continue to grow and in what direction? A study of the ecological and depositional zones already indicated gives many clues to the answers of these questions.

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Methods and Materials

The ecologic zones in Mary Creek were mapped by brunton and alidade. A base line of 440 feet was established and points in the Creek were shot using a brunton to determine bearing, and the alidade and stadia rod to determine distance. The points were then plotted on graph paper and a map was constructed. Depths, at various locations, were measured by dropping a weighted line to the sea floor.

The organisms on the reef front were identified by snorkeling and the use of an "aquanaut," while those in the shallow back zones were identified by wading and the aid of a glass-bottom bucket.

Samples of organisms present in each of the zones were collected and brought back to the lab for identification. Having been identified, the distribution of the organism was noted and mapped.

Results and Discussion: Physical Elements of the Reef Complex

In general the framework of the Mary Creek reefs can be considered the result of three main types of organic accumulation (Kornicker and Boyd, 1962): 1) Rigid frame (massive types of coral), 2) Non-rigid frames (delicate corals), and 3) Skeletal sediment. The reef exists because of the activity of both frame builder types of organisms even though the volumetric bulk of the reef complex itself may be composed of the skeletal sediment and the organisms that live there.

Two types of frame builders exist. First are the primary frame builders of the huge massive corals of Diploria (brain corals) and Montastrea (star corals). The ability of Diploria and Montastrea to build large massive structures on loose sediment is probably the key to the reef origin and to the seaward advance of the reef front. In contrast to these massive primary frame builders are the rigid but less massive secondary frame builders. These are the Acropora palmata and Acropora cervicornis and the Millepora complanata. They are termed secondary frame builders because they must have the foundation of a sturdy primary frame builder before they can grow. An exception may be the Acropora cervicornis as it frequently is found growing on the sandy bottom. However, it is not known whether it can initially begin growth in the sand or whether it spreads by broken off living fragments. Both the primary and secondary frame builders (rigid frames) can thrive under exposure to rough water conditions. This accounts for the presence of the reef and creates the many environmental niches exploited by the non-rigid frame organisms (Table 7).

The non-rigid frames include Porites porites (finger coral), the entire range of Octacorals and such algae as Lithothamnium and Halimeda. These accumulate

only on the protected sides of the more rigid and wave resistant corals (Table 7).

The final type of accumulation is loose sediment. This consists primarily of coral skeletal debris, mollusc shells and their fragments, and algae particles especially from Halimeda. These occur as silt, sand, and gravel of all sizes. Most of the coral rubble appears to be made up of dead Acropora cervicornis, Acropora palmata and Porites porites. The green algae Halimeda (as well as some of its relatives) also plays a role in sedimentation. Each plant consists of many calcareous plates which contribute to the sea floor individual sedimentary particles upon death.

Other algae act as cementing agents for the loose sediment. Encrusting coralline algae plays the dominant part. Their secretions and encrustations add to the bulk of the reef material as they weld together pieces of loose debris **and** cement them to the reef frame. Most of the reef rock itself is made up of coral encrusted to the extent where only the gross form of the original builder can be recognized. Millepora also acts as a cementer as well as a secondary rigid frame in both the fore reef and back reef environment. The hydrazoan appears to be able to grow on everything but loose sand, both building and cementing the reef in its growth process. A final agent acting on the inner zones is the angiosperm Thalassia (or turtle grass) which binds the sediment in its tight network. 10

Zonation of the Reef Complex

The downward sloping area which extends **approximately** 150-200 feet to the windward side of the reef zone and follows the general reef contours is the pro-reef sand zone, made of skeletal coral sand from the reef. To windward beyond this zone is sand with grass which exists as the sea floor prior to reef development.

At the windward edge of the reef the depth of water varies from 7-10 feet. This boundary in all three reefs is well defined, although the growth outlining the leeward side of the reef is less sharply defined and grades into the rubble zone. Reef #1 receives the greatest brunt of the wave action and is also better developed than Reefs #2 and #3. This indicates that the wave action and probably wind direction are important factors in the reef growth. With decreasing power of the waves there also seems to be a decreasing density of active coral growth as is evidenced by the decrease in size and density from Reef #1 to Reef #3. The non-living surfaces of all three reefs are welded and tightly cemented together (encrusting coralline algae and **Millepora) making** the "reef rock" homogeneous in color and texture.

The surf zone of the three reefs consisted mainly of dense growths of Acropora palmata (elkhorn coral) and to a lesser extent growths of Millepora. In many places on Reef #2 the Millepora was so abundant as to form huge ribbon-like patterns on top of previous massive coral boulders, thereby taking on their original shape. In all cases the Millepora was observed to grow out of rigid frame builders living or partially living or out of dead fragments of rigid frame builders incorporated into the reef rock by cementation. Remnant coral boulders of Montastrea and Diploria were also present in the surf zone although not in great quantity and usually half dead and/or grown over with the rigid frame builders (Figure 2, Table 8).

Reef #3 is of particular interest for its accumulation of three species of Acropora. The eastern portion of the reef is entirely A. palmata while the western portion is entirely A. cervicornis. The mid-region however is very interesting in that both A. palmata and A. cervicornis grow intermixed with each other as well as a third species which appears to be intermediate between the other two. Depth of water must be ruled out as a possible controlling factor since it is relatively constant. Some marine biologists list this third type of Acropora as a different species, A. prolifera, but the reef in Mary Creek seems to suggest a possible hybrid between A. palmata and A. cervicornis which is viable and can reproduce itself as a distinct organism. Possibly the evolutionary isolating mechanism, whatever it might be, which has developed to keep A. palmata and A. cervicornis from inter-breeding is not entirely complete. It would only take one reproducing, viable hybrid to initiate a new species and account for the A. prolifera coral evident in the mixed zone of A. palmata and A. cervicornis.

Another characteristic of this third reef concerns the A. cervicornis. Normally, it has many long branches growing out in all directions from a stalk. Below the surf zone on the front of Reef #3 is what we observe. However, within the surf zone, all the long branches are oriented in the direction of wave travel. This is evidently an adaptation which keeps them alive in the rougher water of the surf zone. Still a third form may be found on the shallow water back reef. Here the A. cervicornis forms short stubby thin branches in contrast to long thick ones found in the surf zone and below the surf zone on the fore reef.

At the border between the deep living reef and pro-reef sand are coral boulders of Montastrea and Diploria. Octacorals of all kinds have established themselves below the surf zone on fragments of rigid frame builders. No soft corals were observed growing out of loose sediment. The Acropora species were present on the slope as well as numerous Millepora. Millepora acts both as a secondary frame builder as well as an inhibitor of frame growth, since it will attach to any living or dead coral and begin encrusting it with growth. The colonial anemone Palythoa mammillosa was also quite frequent as an inhibitor of frame growth on the reef front (see Figure 2 and Table 8).

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The back reef, being less sharply defined than the fore-reef, almost merges with the rubble zone. Algae and sediment can be seen killing branches of A. palmata. Sediment as well settles on the horizontal part of the massive corals living in the back reef and rubble zone, killing this area but leaving the outermost and steeply sloping sides to continue growth. Millepora and colonial sea anemones also act here to inhibit coral growth. (See Table 8 for coral location across reef and Figure 1.)

The rubble zone is made up mostly of dead and relatively uncemented coral fragments. Encrusting algae is present (Table 3). Overturned coral boulders, still growing in spots, indicate past storm action. Some smaller nodules of massive star and brain coral as well as broken, but living branches of A. palmata also grow in this zone. The sea urchin Diadema antellarum is very abundant in this zone as they are throughout the reef and pro-reef sand.

There is a gradation of sediment between zones; from rubble to rubble, grass, sand; to grass-sand; and finally to sand and even silt and mud near the man-grove trees of the inner bay. Throughout the rubble-grass-sand and the grass-sand zone white sea urchins (Lytechinus variegatus) and small red urchins (Arbacia punctulata?) are present as well as many Codakia orbicularis clam shells. Sea cucumbers and small gastropods and crabs are abundant in the grass-sand area and large amounts of algae are present throughout both zones (Table 9).

Development of the Reef Complex

The Mary Creek reef complex presents three closed spaced elongate barriers to the open sea. Forces of growth balance the forces of destruction, but the latter are more immediately apparent. The erosive forces overturn the massive living coral boulders at the reef front killing portions of them. On the back of the reef sediment selectively kills the center of living coral masses. The pro-reef sand apron and the rubble and sand zones behind the reef are also the result of the destructive forces. This erosion is accomplished mainly by infrequent major storms rather than day to day surf action. This is evidenced by the fact that there are no freshly broken surfaces of coral or algae cemented reef rock present on the front reef face. The whole surface has a very stable appearance, the reef rock almost entirely encrusted by coralline algae and all types of octacorals and hard corals growing and thriving upon it.

How then does the reef grow? To answer this we must look to the very base of the fore-reef and the pro-reef sandy zone. The pro-reef zone is a fan of sediment (Figure 3) which extends from the lower fore-reef into the deeper water in front of the reef. The zone is characterized by sand rather than the coarse rubble sediment evident in back of the reef. The outward growth of the

reef then is dependent on the extension of frame building activity over the unconsolidated sand sediment. This probably occurs in two ways: 1) Some frame builders (Montastrea and Diploria) seem to be able to attain great size even though the new colony is initiated on a small fragment in the midst of unconsolidated segment. Many colonies of Montastrea and Diploria do indeed rest on loose sand foundations at the base of the reef and into the pro-reef zone; 2) Large colonies or pieces of colonies may be detached from an area of active coral growth, roll some distance down the fore-reef slope, and continue to grow from that position. Overturned living coral boulders of Montastrea and Diploria as well as broken branches of A. palmata and A. cervicornis are observed growing on the sand in front of the reef. From these hard bases spring secondary rigid frames as well as a large variety of flexible frames such as octacorals which must have a solid base for growth.

Behind the living reef, fragments of dead coral are accumulated in the rubble zone. Finer fragments and sand are found further behind the reef and near the shoreline sand alone is found. All these zones behind the reef provide protected habitats for numerous marine organisms, grass-like Thalassia being the most abundant. A cross-section of the reef complex would probably show a slight slope to each zone. The slope probably [results] from a rising sea level over the past 10, 000 years. (Figure #3).

The rate of the outward growth of the reef margin also reflects differences in surf and in available growth nutrients due to prevailing winds and currents. The Mary Creek reef complex directly faces the prevailing Northeast winds and therefore is under direct attack by the waves from the same direction. It is also split into the three reef areas by two channels. A possible explanation is that the calcareous algal growth contributes as a bonding agent of loose debris and thus affects the reef complex as a whole. The cementing action of the encrusting coralline algae is a necessity for the growth of the reef. The secondary frame builders and all the octacorals must have a broad firm platform near the surface in order to expand and survive. Without the calcareous cementing algae the reef rock platform would not exist. Therefore the algae is a necessity in the scheme for reef growth.

Algae needs a continual supply of oxygen which can only come about by increased water circulation which in turn increases the supply of oxygen for nighttime respiration of the photosynthetic algae (Dawson. 1966). Therefore the stronger the surf and the better the circulation the better they grow, and the better job they do in cementing together the reef fragments. Both these elements are present in the Mary Creek complex. First, the reefs face the prevailing winds for maximum surf action, directly bringing in oxygen and nutriments, and second, the two channels provide maximum circulation for the replenishment of oxygen and nutriments. Furthermore there is a hook-like pattern to the reefs in the vicinity of the channels which indicates increased growth in these well-circulated areas. This seems plausible in terms of the increased oxygen and nutriment in this area, but one might also expect that the increased growth around these channel areas would tend toward a closing of the channel. Presently the increased circulation in the main inlet between Reefs #1 and #2 seems to cause growth more along the channel toward the back reef than expanding growth across it. However, the second channel seems to be more on the verge of closing up. It is much shallower than the first channel and many A. palmata are scattered over the bottom, probably broken off from the fringes of Reefs #2 and #3. It seems very probable that this lesser channel could close due to coral growth across it.

Finally, through an understanding of the mechanisms at work at present in determining the reef expansion seaward, it can be *seen* that the origin of the reef itself can be explained in a similar fashion, massive coral boulders being built up in the sand first, other frame builders overgrowing them, etc.

Conclusion

In conclusion, the outward expansion of the Mary Creek reefs into deeper water seems to depend (in the first stage) on some of the massive corals which attain great size but do not require a hard substrate. They create the foundation of reef rock on which, in the second stage, the secondary frame builders can establish themselves and subsequently build up to the water surface. The debris from broken secondary builders is bonded by encrusting coralline algae which play a primary role in the system by creating the reef rock platform. This allows for the continued support and growth of the non-rigid corals and the accumulation of sediment behind them. The outward growth toward the wind and waves as well as the presence of the inlet channels very probably reflects the need for a maximum concentration of oxygen and nutrients in the water engulfing the reef. The oxygen is needed primarily for the production of energy by the photosynthetic encrusting algae which in turn is dissipated in cementing the reef (as well as supplying energy to outer organisms in the eco-system). The water-carried nutrients are of principal importance to the growth and expansion of the living coral.

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CHAPTER III

THE FISHES

CHAPTER III: THE FISHES

Tropical western Atlantic and Caribbean fishes are diverse in taxonomy, distribution and ecology. In this chapter, we will attempt to place the fishes of the Virgin Islands in some sort of perspective for all these factors.

No one knows, with certainty, how many kinds of fish there are in the Caribbean Sea, or how many of these are found around the Virgin Islands. Ross (1968) implies between 900-1,000 in the Caribbean, while Erdman (1968) says that 450 species are recorded from Puerto Rico. We have collected 275 species in the Virgin Islands which are cataloged in the Fisheries Laboratory of the Virgin Islands Ecological Research Station.

Bullis and Carpenter (1968) state that fisheries workers have identified some 1,700 species from the region. Two hundred of these are commercially fished and about 10% of the remainder (150 spp.) could be considered as latent resources. In addition, the shellfish industry uses about 15 species out of 2,500 invertebrates identified. An additional 10% of these are suggested as potential resources. They also state that many additional faunal elements remain to *be* identified.

The inshore and reef fishes of the tropical western Atlantic can be divided into two groups, continental and insular (Robins, 1968).

Continental species require environments where change is a way of life. Such changes as seasonal temperatures, number of daylight hours, storm induced turbidity, run off from large rivers, and so forth have become necessary features in the life histories of these animals. Continental species range out into the shelf area of the larger islands of the Greater Antilles such as Cuba and Hispaniola, but fail to reach the smaller islands in many numbers.

Insular species, on the other hand, cannot tolerate such changes. They require clear, constantly warm water, lying over a bottom which is rich in calcium carbonate (derived from coral). This fauna is best developed in the Bahamas, and large segments of it extend down the island chain to the Virgin Islands and beyond, to the lower Netherlands Antilles. It also occurs on the continental shelf of Central America where the clear Caribbean waters are not much affected by heavy run off of rivers. There are a few widely distributed, ubiquitous species which have the ability to survive almost anywhere. Tarpon, snook and mullet are examples of these highly tolerant species.

The continental fauna, in general, has few species and larger numbers of individuals per species than does the insular fauna. This, in part, contributes to the greater potential for commercial fisheries development on the continental shelf than in the insular regions.

Randall (1968) illustrates and briefly discusses 300 of the common reef fishes which occur in the Virgin Islands; at least 60 of these are utilized in the fishery. Bohlke and Chaplin (1968) discuss 507 species but about the same number (60-70) would concern the fishermen. Randall (1961) took 80 species in traps on St. John. Taken together, Randall (1968) and Bohlke and Chaplin (1968) describe most of the reef fishes of the Virgin Islands but they also include species not found here. The books also omit descriptions of many of the pelagic fishes which occur over the shelf or at its edge.

Table 10 lists most of the pelagic species which are commonly available to the local fishery. In addition, the species of sharks which are known from the islands or exhibit a high degree of probability of being here are listed in Table 11. The list does not include species confined to the depths off the edge of the shelf.

Graphs 2-6 show seasonal catches of five species of pelagic fish over a five and one half year period in the Virgin Islands. January and August temperatures are shown on the same graphs. It can be seen that the graphs represent three general kinds of seasonal occurrence. Marlins reach their local peak in August when waters are warmest, while sailfish are entirely absent during that period and reach their peak in January when the water temperature is lowest. Dolphin are present in large numbers during the late fall and winter, with the highest peak in April. Wahoo are present in good numbers all year but reach their peak in the cooler months of fall, winter and spring. False Albacore also are present in largest numbers during the cooler seasons. It will be noted that there is actually only 1.5 C degrees difference between the ranges of January and August temperatures on the merging side, and 2.5 degrees for the extreme means. There is rarely a temperature difference of five degrees between January and August at the surface of the open ocean around the Virgin Islands.

In the small island masses with their narrow shelves which drop off steeply into deep water, a whole fish fauna, fished heavily along continental slopes, is absent or poorly developed. Bullis and Struhsaker (1968) describe this situation very succinctly in the following paragraph taken from their paper. They are speaking of the continental slope of the western Caribbean where the gradient is gentle and without abrupt drop-offs.

> ...approximately 127 species and species-groups ccur7 in the area between 75-500 fathoms. A characteristic upper-slope fauna appears to be well separated from the outer-shelf fauna at 100 to 125 fathoms and the lower-slope fauna at 350 fathoms. These depths correspond to the 19° C and 7° C isotherms,

> respectively, which are approximately the boundaries of the deep permanent thermocline layer in this region. The fauna reaches its peak diversity and biomass at about 225 fathoms, or the 10° C isotherm. Compared with the upper-slope ichthyofauna of the northwestern North Atlantic, the upper-slope ichthyofauna in the western Caribbean is richer qualitatively, but poorer quantitatively. Fifteen of nineteen species of upper-slope fishes, for which length-frequency data were collected, have a definite size-depth relation — the mean length increasing with depth. The hypothesis is advanced that species demonstrating this relation have pelagic eggs or larvae. The young of these species must acclimate from a warm epipelagic existence to a cold, demersal existence; therefore they tend to first inhabit the shallower and warmer portion of the species' total demersal bathymetric range and then gradually migrate down to the "core" of the population. It was also hypothesized that species showing a weak size-depth relation have young that develop benthonically. The young of these species are already acclimated to the depths inhabited by the adults and therefore tend to occur throughout the bathymetric range of the population.

These latter fishes have been discussed by Ross (1968). According to him there are about 275 species known. Of these, 203 occur in the Gulf of Mexico and 160 in the Caribbean; there are 88 species common to both areas. These fish make up about 30% of the total ichthyofauna of the Caribbean, and are divided into 62 families (of Teleost fish), with 13 of these families containing 80% of the deep-sea species. Even in the deep-sea fishes there is a considerable difference between the Gulf of Mexico and the Caribbean Sea proper. Miller (1968) discusses an "Antillean Barrier" that restricts the distribution of closely related benthic fish species to either the Caribbean or the Gulf of Mexico.

During the course of this project it was possible to gather some details about reef fish populations in terms of taxonomic composition and biomass relative to a given three dimensional area. It was also possible to relate these data to the local inshore pot fishery. One such study is discussed below:

A reef in Chocolate Hole, St. John measuring 75 feet by 120 feet by 30 feet was selected and enclosed from the bottom to the surface of the water by a 1/4 inch mesh nylon net. Line transects were strung so that they crossed the reef in such a manner as to provide equivalents of parallel transects no greater than 1 meter apart. Sessile organisms which the lines touched were counted, measured and identified. The data describing the composition of the reef are presented in Table 6 and discussed in Chapter II.

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On 25 April 1968, three native style "fishpots" or traps were placed in the enclosure. On 11 June 1968 the reef was poisoned with rotenone, the fish collected and the netting removed. On 1 July 1968 the netting was replaced and the "pots" reset. On 13 September 1968 the enclosed reef was re-poisoned, the fish collected and the netting removed. The data resulting from these activities are presented in Tables 12, 13, 14 and 15. It would have been desirable to continue this procedure over a longer period of time but the problems involved in maintaining the net precluded any extension.

There is much discussion about overfishing a specific area with pots, and these data answer, in part, some of the questions which are asked.

It will be noted that at the beginning of the experimental period the reef contained (after fencing) 1,201 individual fish with an approximate total weight of 74.8 pounds. The taxonomic composition was: 29 families, 54 genera, 82 species. In addition there were three spiny lobsters utilizing the reef.

The successive "pot" hauls show an initial "acclimatization" period for the fish, followed by successively larger catches with a final sudden decline. The lobsters were taken in the pots at the time of peak fish catches.

After all the remaining fish were removed by poisoning and the net had been removed, a recovery period of 21 days ensued. The net was then replaced and the pots reset. After a single set no more fish entered the pots and this single set produced a catch slightly lower in weight and number of individuals and species than the first set of the first experiment.

The reef was then re-poisoned and for the second experiment the reef produced approximately 80.8 pounds of fish (more than the first time) distributed among 30 families, 51 genera, 75 species and 1,225 individuals (more thanthe first time). In addition, three lobsters had moved back into the reef along with three Octopus.

While it is true that after only three weeks rest period, the reef had recovered enough to contain more pounds of fish and more individuals with an essentially equal number of taxonomic categories, the composition of the population had changed rather remarkably. There were five new families of fish represented the second time in addition to the Octopus. There were, by the same token, six original families not represented at the second poisoning The overlap brings the total families represented on the reef to 33. Only seven of these were caught in the "pots." The original trapping and poisoning had removed nearly all the commercial food or game fish and the species which invaded the area for the second experiment were forage fish which could only be taken by poisoning. Over approximately six months time the small reef had yielded 155.6 pounds of fish.

The fact that the forage fish moved in rapidly and in large numbers indicated that food or game fish species would find an available habitat and food supply at almost any time in any similar area regardless of the amount of trapping effort.

During the time that the net was in place the first time, 152 food and game fish from adjacent areas in the same small bay had been marked by fin clipping. Only four of these were recovered from the experimental reef during the second experiment. Randall (1961) tagged 4,093 specimens and recovered 1,247. The results thus indicated that in this particular case more than a month would be required for the larger species to move back into an area which had been depleted of them. See also Randall (1963).

Several mechanical problems developed during the course of this study that related to fishing and fisheries that would bear further investigation. The first of these was the problem of keeping sharks or other very large fish from tearing holes in the net. This happened on several occasions and our data do not reflect the possible consequences in population structure. Secondly, the netting fouled badly with sessile growth. This demanded an excessive amount of floatation material at the surface; wave action tended to tear this material off. Thirdly, while observing the reef with SCUBA, divers in several instances recorded that fish entered and left the funnels of the traps seemingly at will. Some experi - mentation with different types of traps might prove rewarding.

Randall (1963b), analyzed the fish populations of an artificial and a natural reef on St. John. He enclosed a fringing reef about 150 feet long by 40 feet wide with a maximum depth of 10 feet. The fish were poisoned, collected and weighed. A synopsis shows 34 families, 60 genera, 103 species, 1,352 specimens with a total weight of 96.05 kg, or approximately 211.3 pounds. He gives no detailed analysis of the structure or composition of the reef but it is slightly larger than our experimental reef and produced more variety and a greater biomass. His figure is .160 kg/m^2. Another reef treated in the same way produced 29 families, 55 genera, 93 species, 1,454 specimens with a total weight of 46.87 kg (about 103 pounds) which gives a standing crop figure of .158 kg/m^2. The results obtained from our study give a figure of approximately 0.034 kg/m^2. This is lower than for the reefs studied by Randall but compares well with studies in Bermuda (0.049 kg/m^2) by Bardach (1959), and by Odum and Odum (1955) in Eniwetok. Because of the near shore fringing character of the reefs studied by Randall it is doubtful that these reefs were regularly fished. The reef in our study is routinely subjected to fishing pressure; without this pressure the fish crop might be larger since we found, as Randall did, that the larger reef fish are hesitant to cross the open turtle grass flats between reefs in order to re-populate a reef. The smaller forage fish moved in rapidly as shown by our consecutive poisonings of the same reef and Randall's analysis of the population rate of a newly constructed reef.

THE FISHES

Randall (1967) has reviewed the food habits of West Indian reef fishes and his synopsis is presented, verbatim, below.

Abstract from Food Habits of Reef Fishes of the West Indies

The stomach contents of 5,526 specimens of 212 species of reef and inshore fishes representing 60 families were analyzed. Most of these fishes were collected by [illegible] in Puerto Rico and the Virgin Islands. The principal plant and animal groups eaten by the fishes are listed by percentage volume of the stomach contents under fish family and species headings. When practicable, the food organisms were identified. Following the species accounts, the major groups of food organisms are discussed.

In the following summary, the various families, genera, and species of fishes are grouped into major feeding categories, based on their principal food habits as determined from the data of this report.

Plant and detritus feeders (food 50 per cent or more plant material): The mullet Mugil curema; the porgies Archosargus rhomboidalis and Diplodus caudimacula; the sea chubs (Kyphosidae); the [illegible] Abudefduf [illegible], Microspathodon chrysurus, Pomacentrus fuscus and P. variabilis; the [illegible] (S[illegible]): the [illegible] Coryphopterus glaucofraenum and Gnatholepis thompsoni (and probably the other [illegible] as well); the angelfish Centropyge argi; the [illegible] (Acanthuridae); the [illegible] Blennius cristatus, B. marmoreus, Entomacrodus nigricans, and Ophioblennius atlanticus; the [illegible] Melichthys niger; and the [illegible] Alutera schoepfi. In addition, the following omnivorous fishes feed heavily on marine plants: the halfbeak Hemiramphus brasiliensis; the [illegible] Pomacentrus leucostictus and P. planifrons; the angelfishes Pomacanthus arcuatus and P. paru; the [illegible] Alutera scripta, Cantherhines pullus, and Monacanthus ciliatus, and the sharpnose puffer Canthaster rostrata.

Zooplankton feeders: The [illegible] (C[illegible]); the round herrings (D[illegible]); the garden eel Taenioconger halls: the [illegible] Hemiramphus [illegible]; the [illegible] Myripristis jacobus; the [illegible] (A[illegible]); the creole fish Paranthias furcifer; the sea bass Serranus tortugarum; the fairy [illegible] (G[illegible]); the [illegible] Amblycirrhitus pinos; the [illegible] (A[illegible]); the sweeper Pempheris schomburgki; the [illegible] Inermia [illegible]; the snapper Ocyurus chrysurus (except large adults): the drum Equetus acuminatus; the scads Decapterus macarellus, D. punctatus, and S[illegible] crumenophthalmus; the damselfishes Chromis cyanea and C. multilineata; the [illegible] Hemipteronotus splendens; and the [illegible] Opisthognathus aurifrons. The following fishes also feed in part on animals of the plankton: the croaker Odontoscion [illegible]; the remoras (E[illegible]); the [illegible] Abudefduf saxatilis; the [illegible] Thalassoma bifasciatum; the triggerfishes Canthidermis sufflamen and Melichthys niger; and the [illegible] Monacanthus ciliatus and M. tuckeri. In addition, the juveniles of many fishes such as the pomadasyids and carangids feed primarily on zooplankton.

Sessile animal feeders: Abudefduf saxatilis and to a lesser extent several other damselfishes; the spadefish Chaetodipterus faber; the butterflyfishes and angelfishes (Chaetodontidae) (except C. argi); the filefishes Alutera scripta, Cantherhines macrocerus, and C. pullus; and the trunkfishes Acanthostracion polygonius, A. quadricornis, and Lactophrys bicaudalis. The angelfishes and C. macrocerus feed primarily on sponges; the sharpnose puffer Canthigaster rostrata and some of the trunkfishes also feed in part on sponges. Abudefduf saxatilis feeds on a wide variety of organisms, but the largest percentage of its stomach contents proved to be Zoanthus. The butterflyfishes consume mainly anthozoans (especially Zoanthus) and the tentacular crowns of tube-dwelling polychaetes. Alutero scripta is unusual in feeding heavily on stinging coral (Millepora) and gorgonians. The three trunkfishes appear to show a preference for tunicates. Many of these fishes also feed in part on plants.

"Shelled"-invertebrate feeders: The eagle ray Aetobatis narinari; the grunts Anisotremus surinamensis, Haemulon carbonarium, H. macrostomum, and to a lesser extent H. plumieri and H. sciurus; the porgy Calamus bajonado, and to a lesser degree other species of Calamus; the permit Trachinotus falcatus; the wrasses Bodianus rufus, Halichoeres spp. (except maculipinna), Hemipteronotus novacula, and Lachnolaimus maximus; the triggerfish Balistes vetula; the trunkfish Lactophrys trigonus; the puffer Sphaeroides spengleri; and the porcupinefishes (Diodontidae). All of these fishes are able to crush their prey of gastropods, pelecypods, echinoderms, crabs, and hermit crabs with their jaws or pharyngeal teeth.

Generalized carnivores (on a variety of mobile benthic animals such as crustaceans, worms, and small fishes): The stingray Dasyatis americana; the moray Echidna catenata (all crustaceans, mostly crabs); the snake eels Myrichthys acuminatus and M. oculatus; the squirrelfishes Holocentrus spp. ; the groupers Alphestes afer, Cephalopholis fulva, Epinephelus spp., Hypoplectrus spp., Petrometopon cruentatum and Serranus tigrinus; the soapfish Rypticus saponaceus, the snappers Lutjanus spp. (except L. cyanopterus which feeds on fishes, as to a lesser extent do L. apodus, L. jocu, and L. mahogoni); the grunts Anisotremus virginicus, Haemulon album, H. aurolineatum, H. chrysargyreum, H. flavolineatum, and H. parra; the mojarras (Gerreidae); the drums Equetus lanceolatus and E. punctatus; the goatfishes (Mullidae); the tilefish Malacanthus plumieri; the palometa Trachinotus glaucus; the wrasse Halichoeres maculipinna; the flounder Bothus ocellatus; the clinids Labrisomus spp.; the jawfishes Opisthognathus spp. (except O. aurifrons); the scorpionfishes (Scorpaenidae); the flying gurnard Dactylopterus volitans; the trunkfish Lactophrys triqueter; and the batfish Ogcocephalus nasutus.

Ectoparasite feeders: Juvenile porkfish Anisotremus virginicus; the shark suckers Echeneis naucrates and Remora remora; the wrasses Bodianus rufus and Thalassoma bifasciatum (the former as juveniles, the latter as juveniles and adults except the terminal male phase); the goby Elacatinus sp. ; and juvenile angelfishes of the genera Holacanthus and Pomacanthus. In addition, the fairy basslet Gramma loreto and the young of the damselflsh Microspathodon chrysurus occasionally feed in part on the crustacean ectoparasites of fishes. Probably none of these fishes are facultative "cleaners." The shark suckers, Thalassoma bifasciatum, and the young angelfishes appear to feed more on other organisms than on fish parasites.

Fish feeders: Sharks of the families Orectolobidae (reported to feed heavily on various invertebrates as well) and Carcharhinidae; the tarpon Megalops atlanticus (also known to feed on crustaceans and other invertebrates); the lizardfishes (Synodontidae); moray eels of the genus Gymnothorax; the snake eel Ophichthus ophis; the needlefishes (Belonidae); the cornetfish Fistularia tabacaria; the trumpetfish Aulostomus maculatus (about 1/4 of the diet was shrimps); the barracudas (Sphyraenidae); groupers of the genus Mycteroperca; the sea bass Serranus tabacarius (one specimen); the snapper Lutianus cyanopterus; the cobia Rachycentron canadum (one specimen); jacks of the genera Caranx, Oligoplites, and Seriola; the little tuna Euthynnus alletteratus and mackerels of the genus Scomberomorus; the flounder Bothus lunatus; and the frogfishes Antennarius multiocellatus (about 1/5 of the food was crustaceans) and A. scaber. A number of the above piscivorous fishes fed in part on cephalopods, but in all cases except Ophichthus ophis (half of the stomach contents of four of these eels consisted of octopuses) and Euthynnus alletteratus (36.6 per cent squids), the cephalopods were less than 18 per cent by volume of the stomach contents.

Erdman (1968) has reported on the spawning seasons of game fishes around Puerto Rico. Tables 16 and 17 are adopted from his report and project data are incorporated into the tables as a method of presenting all available information in one place.

CHAPTER IV

THE FISHERY

THE FISHERY

During the course of this study an effort has been made to estimate the "fishing pressure" in the islands, and to relate this to an estimated potential fishery. No data are available which allow a "tons per year" evaluation of the potential, but some empirical conclusions have been drawn and these are presented and discussed in the final chapter.

The present chapter is divided into three very unequal parts for the sake of convenience, but in reality they overlap considerably. The first part is a very brief review of the sport fishing charter boat industry; the second is concerned with the various aspects of the purely "commercial" fishery; and the third is designed as a booklet for separate distribution to the visiting light tackle "inshore" and "onshore" fisherman; it attempts to guide the fisherman to the most readily available fishing spots on each of the three major U. S. islands and to indicate enough about the water and the shoreline to aid him in his choice of where to go. The brief notes about tackle, baits and preferred habitats for a few commonly caught species can be matched with descriptions of the habitats provided by each site so that the angler's chancesof catching a particular species are enhanced.

No effort has been made during the course of this study to analyze the effects that divers may have on fisheries resources. The number of divers and spearfishermen who harvest fin fish and shell fish increases each year and some of the same problems that have arisen in Florida and other coastal states will no doubt appear in the Virgin Islands. It is our opinion that harvesting by diving can be a very selective process that could make valuable contributions to conservation practices in the islands.

The charter boat industry sometimes enters the "comm ercial" area when "sport" fish are sold by the crew. No records of sales from such boats are available. However, our observations lead to the conclusion that charter boat sales contribute several tons of fish per year to the local consumers market (see Table 10 and Graphs 2-6).

Our observations also indicate that a great many pounds of fish are killed and wasted each year without entering the market. This is particularly true of blue marlin which find little acceptance as a local food. Efforts to promote the tagging and release of most bill fish have been partially successful in reducing this waste of a valuable resource (Table 10). Since offshore trolling usually produces the larger specimens of such species as barracuda, jacks and groupers, these larger fish are discarded for the most part because of the possibility of their being poisonous. *(See* Chapter V). All sharks caught by charter boats are routinely killed and cut off at the transom since there is no local market for any shark product. Some boats have logged as many as 50 sharks per year while trolling for other fish.

THE FISHERY

From what has been said above, and from the partial catch records (Table 10, Graphs 2-6), it will be seen that the charter boat sport fishing industry in the islands contributes to both the retail consumer market and the fishing pressure on the populations which are caught. Compared to a full-fledged commercial seine, or long-time operation, the pressure exerted by charter boats on fish populations must be negligible. However, it is still too early to compare total fishing impact on the Virgin Islands fishing waters with the impact of the fishing effort in a state like Florida. Table 18 indicates the very few charter boats in the Virgin Islands and the very short time over which they have operated. It has not been possible to find out how many boats of various categories are registered in the American Virgin Islands. Motor boat registrations are not kept in a manner which allowed tabulation by this project. Florida in 1968 boasted 166,146 pleasure boats, 30,542 commercial boats and 294 marinas. It has not *been* possible to analyze in detail the number of acres of aquatic habitat in Florida as compared to the number of boats and the time period over which they have been operating, but it almost seems self-evident that the Virgin Islands, with their relatively undiversified marine habitats and no fresh water habitats, will become boat-saturated at a much more rapid rate than Florida.

A SURVEY OF THE COMMERCIAL FISHERY OF THE VIRGIN ISLANDS OF THE UNITED STATES

Introduction

Past surveys of the commercial fishery of the United States Virgin Islands either are considerably outdated, were not comprehensive, or did not include all three of the major islands. The only previous study that included St. Thomas, St. John and St. Croix occurred in 1930 (Fiedler and Jarvis, 1932). In 1959 (Idyll), a survey of the commercial fishery of St. John was made at the request of the U. S. National Park Service. A brief summary of the St. Croix fishery was presented in 1961 (anon.) to a meeting of Caribbean Fisheries Officers in San Juan, Puerto Rico. The present survey was undertaken in order to provide up-to-date and complete information on the various aspects of the fishery in all of the American Virgin Islands, and on the consumption of seafood products.

Investigation Problems and Procedures

Collection of accurate fishery data in the Virgin Islands is difficult, at best. There are no licensing or registration requirements for fishermen or their gear, although motor boat registration is mandatory. The absence of any organized distribution system for the fishery makes the procurement of accurate catch statistics impossible. The Virgin Islands Code, which is the territorial "constitution," does not provide for salaried enforcement officers to check on seafood catches and, consequently, there is no enforcement of the regulations; nor is there much contact with the fisherman by any government agency. Additionally, since seafood caught by foreign flag vessels may be landed freely in U. S. Virgin Islands ports, with only a rather general cargo identification being required, Customs information is not very useful in determining species and quantities landed by these vessels. Finally, it should be pointed out that the fishery is composed of many individual efforts and there is little inter-communication; fishermen are seldom acquainted with the overall fishery, with persons or techniques in the other islands, or even with the fishery in other sections of their own island.

The above mentioned problems made the use of any random sampling technique inappropriate. Consequently, the sampling procedure consisted of interviews with commercial fishermen, with boat captains importing freshly caught seafood and with seafood handling outlets. The data from this sample were expanded, when appropriate, to correspond to the whole population.

Non-professional divers, who constitute a group which occasionally harvests lobsters and fish for profit, were completely excluded from this survey. Another group that puts fresh fin-fish on the local market is composed of the charterboat operators; because virtually no usable data were forthcoming from this group, their production is not included in the statistics.

SURVEY OF COMMERCIAL FISHERY

Aerial counts were made of fish pot buoys and fishing craft in U. S. Virgin Islands waters. From these aerial surveys, and from interviews, areas of concentrated fishing effort were determined for each of the three islands. Each such area and each marketing location was then visited regularly, to interview fishermen. Each fisherman, in turn, was asked to suggest other fishermen who might be interviewed, and to indicate where other fishermen could be found.

The Virgin Islands Department of Commerce indicated that it had made recent estimates of the number of fishermen in the population, for the F.A.O. Division of the United Nations, the estimates having been made on the basis of sampling and census figures. The authors of the present report, using different methods (boat and pot counts, fishermen interview), arrived at corroborative figures.

Approximately 400 persons were engaged in commercial fishing activities in the American Virgin Islands in 1967. Of these, 83 (or 69%) of the estimated 120 full-time fishermen were contacted during this survey, as were 70 (25%) of the 280 part-time fishermen. Fishermen were asked questions regarding personal data, income, gear, fishing effort, catch, handling and marketing, ciguatera, the need for government services or regulations and, finally, any general observations and comments, with particular reference to recent changes in the fishery. Only one fisherman had records; information from other fishermen was based on their estimates.

Interviews were also conducted with 34 fishermen operating from the British Virgin Islands; this represented all but two of the known boats that regularly brought local seafood into the U. S. Virgin Islands from the British Virgin Islands. Only a few of those that seldom landed such seafood were contacted; these boat captains were approached with questions similar to those asked of the other commercial fishermen.

All of the wholesale and retail grocery stores in the American Virgin Islands were contacted. Operators of private restaurants and of government supported dining halls were also interviewed. Thus, the major commercial seafood outlets -- and certainly more than 90% of the total number -- were interviewed. The operators of these outlets were questioned about their consumption of seafood, which, for purposes of this survey, was separated into three categories according to place of origin: local (including imports from British Virgin Islands), Puerto Rico and U. S. mainland imports, and foreign (all others). Canned seafood products were excluded from all categories.

These outlet operators were also questioned about their seafood sources, prices paid for seafood, adequacy of supply, local seafood preferences, desirability of additional local seafood availability, extent and types of processing and preservation of local seafood purchased, and their willingness to pay increased prices for additionally processed food.

When available, records of seafood purchases by these outlets were utilized; otherwise the data provided were based on estimates made by purchasing personnel at each establishment.

The survey was conducted during the first half of 1968. This report covers a twelve month period, almost all of which was in 1967, with the small balance in 1968. In some cases, statistics for the calendar year 1967 were used. No significance is attached to these period differences. Data concerning fishermen population, boat registration and census were obtained from the Government of the U. S. Virgin Islands. Import statistics were procured from the U. S. bureau of Customs, unless otherwise noted.

Sampling was done by biologists of the Virgin Islands Ecological Research Station, with occasional assistance from biology students attending the College of the Virgin Islands.

RESULTS

A. General Fishery Description

The fishery of the Virgin Islands is primarily based on the use of fish traps (or "pots," in local terminology). These pots are usually constructed of heavy gauge pre-woven poultry netting, and are made in the form of a chevron, with a single entrance, or "funnel," located at the apex of the concave side. Mesh sizes vary from 3/4" to 2", depending on the choice of the individual fisherman. The pots are then "braced" with "sticks" from one of several varieties of local woods, on the top, bottom and sides. A door is provided for removal of the catch. This might be termed the "classical" construction, since it has been used for several generations, and is prevalent throughout the Caribbean area.

A few of the hand-woven, unbraced "hard wire" pots are still made and used, but these are very rare, due to difficulty in obtaining materials; the construction is also very time-consuming and there are not many of the present generation of fishermen who know how to make this type of pot.

A few fishermen are using new materials for the mesh -- especially the welded mesh chicken cage wire, both plastic covered and galvanized, the latter occasionally being protected by a replaceable zinc anode. Reinforcing steel, such as that used in building construction, is occasionally used for bracing in place of the wooden sticks. One fisherman was using 1/2" galvanized steel pipe for the main bracing, the pipe having been laboriously bent and bolted together; a few side sticks were affixed for additional rigidity.

The pots are set on the bottom of the sea, usually with a line and one or more buoys attached, and are hauled either by hand or by winch, at regular intervals, from boats that are generally small, open and locally built. Pots are set both with and without bait.

Some fishermen use nets (usually cotton), either exclusively or in conjunction with other gear. The nets used in the Virgin Islands fishery are primarily haul seines; sets are made on or near a beach and the net is hauled ashore. No purse seines or gill nets, as such, were in use in the Virgin Islands fishery at the time of the survey, although a very small and modified tangle net was occasionally used, by a very few fishermen, to catch turtles. The haul seine catches are predominately either bait or the little tuna Ethynnus alletteratus, and the jacks Caranx crysos and Caranx ruber. Due to the nature and location of net sets, the harvest of migrant schooling fish by this method is extremely limited.

Many fishermen use hook and line techniques in conjunction with other gear, but very few use this method of fishing exclusively. Hand lines are the rule, with very few using rod and reel. Line fishing techniques were only occasionally used for trolling; most hand lining occurs while the boats are at anchor and the fishermen are "banking" for fish in deep water (600 - 1200 feet), bottom fishing in shallower water or "chumming up" other fish.

Another fishing technique, now almost out of existence in the Virgin Islands, is termed "fundering." This consists of lowering a thoroughly baited fish pot (often with bait on the outside as well as inside of the pot to induce a "feeding frenzy") to depths of 600 feet or more. After a suitable interval of time, which is determined by the fisherman's experience and the location being fished, the pot is hauled up; the catch is taken out and the pot is re-baited and lowered again. Often, several pots may be used to make the operation more or less continuous. Catches by this method were reportedly occasionally spectacular (up to 200 pounds of fish per pot per set), but the technique is rarely used anymore because the effort is considerable and the reward is less than that realized from other fishing practices.

Although these other types of fishing activity frequently yield good catches, fishing with pots in fairly shallow water is still the principal method of harvesting seafood in the Virgin Islands.

The fishery is a continuous operation, engaged in by a small number of persons, generally with a limited amount of gear and a limited capital investment. Although almost every species of fish is saleable, the landings fall far short of satisfying the local demand and large quantities of seafood products are imported into the islands.

The not infrequent incidence of ciguatera poisoning limits the sale of some species and sizes of fish; some commercial purchasers of seafood refuse to buy any local fish, due to fear of such poisoning. The price paid for locally caught fish is high, by U. S. mainland standards, but fish remains a highly regarded staple in the diets of Virgin Islanders.

Fishermen generally sell their catches directly to the consumer, although some sell directly to commercial outlets such as groceries and restaurants. There are no fishermen's cooperatives, and there are almost no commercial distributors engaged primarily in the purchase and sale of local fishery products; the absence of these makes it nearly impossible for the commercial outlets to obtain local seafood on a consistent basis, and these outlets tend to rely on imports, only occasionally supplementing this fare with local products.

Modern techniques of handling, and of portion and quality control, are almost entirely lacking in the Virgin Islands fishery. Local fish are sometimes sold live, but usually dead, and seldom have they been gutted or scaled. Ice is used consistently only by a very few fishermen. These practices, which are based to some extent on customer preference, result in a certain amount of spoilage and loss of fish, and in occasional cases of consumer poisoning. When fish are frozen or iced, this is usually done with the viscera intact. There appears to be little likelihood of modification or change in current handling practices, since, normally, fishermen can readily sell their catches without the additional effort or expense involved in further processing or preservation.

B. Other Data and Discussion

In 1930, in a population of 22, 012, there were 405 fishermen in the American Virgin Islands (Fiedler and Jarvis, 1932). Although by 1967 the population had increased to approximately 55, 000, the estimated number of fishermen was still about the same, 400. Relative to the entire population, this represents a decrease of 60% in the number of fishermen.

Fishermen counted in the 1930 survey were probably almost entirely native-born American Virgin Islanders. The present survey, however, showed that only about half (56.3%) of the present day local fishermen were American Virgin Islanders by birth, indicating that the percentage of native born fishermen in the entire population had decreased by about two-thirds during the 38 year period between surveys (Table 1). In addition, as can be seen in Table 2, the average American Virgin Islands fisherman was almost 45 years of age and had been fishing for 19 years. Unlike many other occupations, commercial fishing involves much hard physical work, and the above data point to the fact that fishing, as a vocation, is attracting fewer of the younger generation.

This situation is undoubtedly related to the spectacular rise in tourism in the Caribbean area and the attendant increase in related business activity resulting from tourism, as well as to the increase in local industrial enterprises and to the greatly expanded government employment which has resulted. The younger generation is turning to occupations in these areas, rather than to strenuous and hazardous jobs such as fishing; the monetary return is much higher, and little or no risk is involved.

Substantiation for this possibility appears in Table 1, which shows that St. John, which has been less affected by tourism than her sister islands, St. Thomas and St. Croix, had a fisherman population almost entirely native to the island. St. Thomas, on the other hand, which has been most affected by tourism and increased government activity, and where the market for seafood is many times greater than in the neighboring British Virgin Islands, had almost as many fishermen who were born in the British Virgin Islands as it had native St. Thomian fishermen.

Reported investment, expenses and income are given in Table 2. The reader should bear in mind that the income and catch data for fishermen are apt to be lower than actual values. There appeared to be a considerable hesitancy on the part of many fishermen to report these figures accurately. Although the interviewers always assured the fishermen that the information sought was solely for use in compiling general survey data for the College of the Virgin Islands, and that no specific information would be given -- or be made available -- to other branches of the Virgin Islands Government (particularly the income tax division), it seemed quite obvious in many cases that the reported catch and income figures were low. In a very few instances, where catch and income did not correspond, one factor was altered to match the other. Generally, however, there were no discrepancies (or only very minor ones), and the authors have chosen to report figures, except as noted, as received. There seems to be no reason to question the accuracy of other information contained in this survey. In a few cases, the fishermen interviews were not complete, and the varying sample size indicated in the data reflects this.

With the exception of those in St. Thomas, the average part-time fisherman's capital investment exceeded his net income. In St. John, the ratio was more than three to one. It is indicators such as this that led the investigators to question the accuracy of reported incomes and catches. However, even if the income figures are below actual values, the indication is still that, particularly for the full-time fisherman, fishing income could hardly be considered adequate enough to seem enticing to the young man choosing a career.

The investment/income ratio for the average full-time St. Croix fisherman was considerably higher than it was for the average full-time fisherman on St. Thomas and on St. John, due to the larger investments in fishing boats of the former.

Although there were more fishing boats in St. Thomas and St. John combined, total boat investment in St. Croix was nearly three times as much (Table 4).

The vast majority of boats used in the Virgin Islands fishery were small (14 to 20 feet) open boats, almost always locally built, often by the fishermen themselves. Propulsion was predominantly by outboard gasoline engines, averaging less than 20 horsepower (Table 3). Less than 7% of the fishing boats in St. Thomas and in St. John were inboard-powered, whereas more than 21% of the St. Croix fishing vessels had inboard power. This difference is explained by the fact that many of the St. Croix vessels were large, venturing farther -- up to 100 miles -- to catch and to sell seafood. Almost half of the British Virgin Islands fishing vessels which landed catches in the U. S. Virgin Islands were powered by inboard diesels, with some additional sailboats with diesel auxiliaries. This is to be expected, due to the longer distances these boats travel to the St. Thomas market; diesels were used, to the complete exclusion of gasoline inboards, due to the considerably lower cost of diesel fuel and the better dependability of diesel engines.

In addition to a capital investment breakdown of boats and gear, **Table 4** also indicates the number of fish and lobster pots in use and the total length of nets being used at the time of the survey. The number of pots refers only to those in actual use and did not include pots that had been lost or stolen, or that had been made but not yet put into service. (Lobster pots were used only in St. Croix and the British Virgin Islands. Fishermen caught both fish and lobsters in fish pots in St. Croix and the British Virgin Islands, whereas the lobster pots caught only lobsters. Fish pots in the St. Thomas and St. John waters were not reported as having caught lobsters.)

A summary of Table 5, given below, clearly shows that the fish pot was the basic unit of gear in the Virgin Islands fishery.

GEAR USE

	Exclusive	Partial	Total
POTS	71	84	155
NETS	12	59	71
LINES	13	77	84

155 of the 187 fishermen interviewed used pots either exclusively or in conjunction with other gear. 71 used pots exclusively, whereas only 25 fishermen used either nets or line fishing techniques exclusively. The basic reasons

for the popularity of fish pots are that they are easily built and are inexpensive, relative to the amount of fish caught with this gear. In addition, it takes very little skill to fish with pots.

Hook and line fishing, on the other hand, while requiring a small investment, requires considerably more ability and knowledge of fish habits. The successful use of nets also requires a certain degree of skill, as well as the cooperation of many people in the setting and hauling. In addition, the initial investment in the average net is large; whereas a fisherman can begin fishing with only a few pots, he cannot fish with only a small piece of net. The use of nets has also apparently declined in recent years as more beaches become parts of hotel operations or actual hotel sites. In addition, the advent of the Virgin Islands National Park in St. John has closed many other beaches to seining activities.

Gear and catch averages are given in Table 6. Some statistics derived from this table appear below:

	A	B	C
	Hauls/Week/Fish Pot	Annual Catch Per Man (Fish Only, lbs.)	Ratio (B/A)
St. Thomas	2.5	6628	2651
St. Croix	1.7	3680	2164
St. John	2. 0	1604	802
U. S. V. I. Average	2.1	4551	2167
B. V.I.	2.3	7237	3144

Interpretation of these data is somewhat complicated by the probable downward bias in some catch reports and the lack of specific data relating catches to type of gear used. Nevertheless, the figures in the columns and a ratio of the figures in columns A and B can be used for comparative purposes, since column A is an indicator of effort and column B is an indicator of results for the effort expended.

The St. Thomas fishermen hauled their pots more often and they also caught more fish per man than in the other two American Virgin Islands. The B/A ratio for St. Thomas is above the American Virgin Islands average; the fishing seemed to be good here. St. Croix, where the effort and annual catch per man were both low, has a B/A ratio which is almost the same as the total average; fishing here was only fair. St. John, with about an average degree of effort, had a very low annual catch per man and a very low B/A ratio, which indicates that either the fishing was definitely poor or the catch reports were markedly low. While the St. John fisherman may be able to live on a smaller income than his St. Thomas or St. Croix counterparts, it seems very unlikely that an income only 35% to 45% as high (see Table 2) would be adequate; low catch and income reports appear to be the logical explanation for the low St. John ratio.

In the British Virgin Islands, the effort was greater than in the American Virgin Islands. The annual catch per man was also higher than for any of the American Virgin Islands, as in the B/A ratio. It would seem that the fishing was best in these neighboring British islands.

Although the St. John income and catch data are indefinite, so that no accurate interpretation can be made, it is notable that the observations concerning St. Thomas, St. Croix and the British Virgin Islands were confirmed by persons who have fished in these three areas. St. Croix is known to have suffered from the dredging operation along its south shore, in the Harvey-Hess industrial area particularly, and fishing there was not as good as in St. Thomas (numerous news and verbal reports from scientists have indicated it may be as long as 40 years before the effects of these dredging operations subside completely). The British Virgin Islands, on the other hand, which were relatively unspoiled, and had certainly been less extensively fished (partly due to the size of the area and to its relative inaccessibility), yielded consistently better catches for the effort expended; several fishermen from both St. Thomas and St. Croix were fishing in the British Islands regularly for just that reason.

A complete listing of the types of baits used in pot fishing appears in Table 7. Considering that 22 different types of bait were being used, it appears that bait choice was based more on availability and on individual fisherman preference than on proven fish-attracting qualities. There were, however, three notable exceptions. Both sprat (genus Harengula) and conch were well-proven fish baits; both were relatively abundant and were also used as baits for hook and line fishing. The other exception was that an appreciable number of fishermen used no bait whatsoever in their pots. It was explained by some fishermen that the catch from a baited pot seldom exceeded the catch from an unbaited one, and that the time, effort and expense of baiting traps were thus not warranted. Others suggested that, once the pot had become "fishy" (algae-covered) the smaller reef fishes became attracted to the pot by the algal growth, and the bigger fish went into the pots after the smaller fish anyway, so no bait was required. Some of these fishermen did hasten the process by leaving a few small live fish in the pots after each haul; this seemed to work quite well, but was not considered "baiting" the pot.

Fishermen observations of the trends of catches and monetary returns are given in Table 8. The vast majority of fishermen reported that the catch per unit of effort had either remained the same or decreased (where a double opinion was reported, both were included), but there was general agreement that the monetary return had increased. The latter is to be expected, since the price of fish has increased continuously from ten cents per pound maximum in 1930 (Fiedler and Jarvis, 1932) to an average of 50 cents per pound in 1967-68, much of this increase having occurred during the last few years.

The reports that the unit catch had remained the same, or decreased, are attributable to several factors, among which is a rather apparent lack on the part of the local fishermen to change their practices in order to take advantage of modern fishery techniques. It should be noted, however, that many of the modern techniques cannot be employed without very sizeable investments, which are almost entirely beyond the means of local fishermen. The modern practices which could be utilized with relatively small capital outlays are often difficult -- or impossible -- to put into practice, due to a frequent local tendency to resist changes, to non-availability of specialized gear (or the difficulty in obtaining it), and to the seeming lack of interest on the part of the local government in improving the fishery.

Problems reported by the fishermen are listed in Table 9. Loss of gear, weather, and theft of gear are the problems reported most frequently, and these are, to some extent, connected. Loss of gear definitely occurs when larger vessels cut or foul buoy lines, and, in St. Croix, this was a real problem for many fishermen. The larger tankers and freighters -- which passed along the south shore, especially en route to and from the Harvey and Hess plants -- seemed to take varying routes, and fishermen were hard put to find fishing areas over five fathoms deep where the large vessels did not travel. This situation applied all around the islands, to varying extents, as more and more motor vessels (both commercial and pleasure) of all sizes were being operated in the area.

Weather was a problem insofar as rough seas are not infrequent and may continue for several weeks at a time. Although this did not normally prevent all fishermen from tending their pots, it did make the locating and hauling of pots much more difficult. Bad weather also accounted for loss of gear and, in some instances, for rather large losses, particularly during the hurricane season when hurricanes or severe storms pass through the islands, causing very rough seas and strong currents. Buoy lines chafe and are cut on bottom coral, pots get tumbled and smashed and sometimes are swept away, presumably to deep water where they cannot be found. (An interesting comment, made by several fishermen, was that catches in pots which could be found after a severe storm were often many times better than average.)

Loss and theft of gear are also related. Theft was frequently suspected, but may not have been the cause of gear loss. There were known cases, however, where theft of gear had occurred; but, until better government enforcement is available, very little can be done about this problem. The same applies to loss of fish, which refers to pots being hauled and emptied by people other than the owner. This occurrence had been witnessed many times, but little could be done about it. Theft was apparently on the increase, as it was on land; Idyll (1959) reported theft as almost non-existent on St. John at that time.

Although engine trouble and spoilage were considered problems, these were basically caused by inattention or poor practice on the part of the fishermen themselves, who are the only ones who can overcome these particular difficulties.

Marketing was considered a problem, chiefly by those who travelled longer distances to sell their catches, or, upon occasion, when large catches were made. The marketing aspect seemed to have changed little since 1930, when Fiedler and Jarvis observed that the Fishermen in St. Croix preferred to "sell a small quantity at a high price rather than a large quantity at a lower price." In addition, many marketing problems were eliminated by the very nature of the marketing system in effect at the time of the present survey. It was common practice to sell fish in groups, by the string, with the most desirable and the less desirable fish on the same string to ensure the sale of the entire catch. In some areas (particularly St. Croix), the same result was achieved by the fisherman insisting the customers "mix" the fish being purchased, even though fish are sold on a per pound basis. Generally, all species sold for 50 cents per pound and were sold whole and uncleaned. The price was sometimes lowered for large purchases or to encourage a quick sale.

It is surprising that pollution was reported as a problem by only one fisherman, but this may have been due to the lack of knowledge of the pollution that did, indeed, exist, or it may possibly be explained by the fact that the effects of pollution are not so dramatic nor so immediate as those caused by severe weather or theft.

Apparently, the fishermen were satisfied with the types of gear being used; only one reported cost of equipment as being a problem. As is probably true in any field of endeavor, very few individuals reported no problems at all.

Fishermen were asked what government services or regulations might be helpful to them. Almost a quarter of the fishermen felt the government should neither assist nor regulate the fishing activities (Table 10). It is worth noting that almost half of the St. John fishermen held this opinion. However, the majority of fishermen felt that some type of government assistance would be desirable. A loan program was listed first, with improved marketing facilities a close second. It appears that, while some did not consider marketing a problem, they still felt that better marketing facilities would be beneficial. The Government of the U. S. Virgin Islands had begun construction of a market storage facility for St. Thomas at the time of the survey, and had appropriated $40,000 for renovation of existing market places in St. Croix.

The third rated request was for government operated cooperatives, similar to those in Puerto Rico, where fishermen could purchase gear and materials at reduced costs. Some St. Croix fishermen requested action which would alter navigation routes of the Hess and Harvey vessels, which reflects their concern about gear loss as mentioned earlier. Pollution abatement regulations were requested only by St. Croix fishermen, reflecting the fact that the dredging at the Harvey-Hess complex had caused a more dramatic and readily visible pollution than in most other areas in the Virgin Islands at that time. Some fishermen had found it no longer profitable to fish on the south and southwest shores of St. Croix, but did not request that the Harvey-Hess pollution be controlled since they had moved their fishing operations to other areas.

A third of the St. John fishermen requested that the National Park beaches be opened to seining operations. Other miscellaneous services were requested by only one or two fishermen, while six had no opinion.

Table 11 presents customer fish preference, as reported by commercial fishermen. Blue runner and grouper were listed as first choices, with yellowtail snapper and other snappers (except red snapper) as third and fourth choices, respectively. The blue runner may owe part of its distinction to the fact that it was usually sold at a lower price than most fish, since normally large catches were taken by net and the price was reduced for a quick sale. Parrot fish and surgeon fish apparently sold much better in St. Croix than on other islands. A relatively high percentage of fishermen indicated no customer preference; this may be due, in part, to market techniques previously described: selling assorted fish by the string, or by "mixing" fish when sold by the pound.

Although Table 11 includes most of the local fish entering the market (excepting some species caught by charter boat operators), other species were commonly sold by commercial fishermen: trunkfishes (Ostraciontidae), triggerfishes (Balistidae), hogfishes (Lachnolaimus maximus), damselfishes (Pomacentridae), angelfishes (Pomacanthus spp. and Holacanthus spp.) and morays (Muraenidae).

Fishermen reports of local fish which were apt to be ciguatoxic are given in Table 12. It will be noted by comparing Tables 11 and 12 that many of the species high on the list of consumer preferences were also listed as being commonly ciguatoxic. The major factor which explains this anomaly is fish size; whereas the larger specimens of the species listed in Table 12 are highly suspect, most persons readily eat the smaller specimens. Another factor is the location in which the fish were caught (*see* Table 13); fish caught in certain areas were suspected of being ciguatoxic.

SURVEY OF COMMERCIAL FISHERY

The great majority of fishermen considered the barracuda to be ciguatoxic, especially the larger specimens (over five pounds). Eight members of the jack family were considered ciguatoxic, especially the larger specimens, amberjack and horse-eye jack. In general, resident piscivorous species appeared to be most commonly suspected of being ciguatoxic; oceanic pelagic species, except large kingfish, were never suspected. Schooling jacks were considered safe, while the same species were considered dangerous if caught without evidence of having been part of a school. The majority of the fishermen interviewed had been poisoned by ciguatoxic fish at one time or another.

Areas from which fish were reported as being frequently ciguatoxic are listed in Table 13. The predominant statement was that ciguatoxic fish can come from any area, and that the ciguatera is caused by other factors, such as the time of year (primarily spring), copper from the mines and sunken ships, or the ingestion of moss (algae). The areas most frequently reported as producing ciguatoxic fish in the American Virgin Islands were on the south sides of St. Thomas and St. John or near small islands south of St. Thomas. No particular area near St. Croix was especially identified as producing ciguatoxic fish.

The methods used to identify ciguatoxic fish are listed in Table 14. The methods reported are so varied and so infrequently reported that the techniques cannot be given much credence. The overwhelming majority of fishermen reported that there was no method of identifying ciguatoxic fish at the time of sale. The most common technique used by customers purchasing suspect fish was to feed a portion of the fish to a cat and to see if the cat either rejected the fish or became ill; if neither, the fish was presumably safe for human consumption.

Prices paid for seafood in the American Virgin Islands at the time of this survey are listed in Table 15. These average prices were used in computing value of landings and imports in subsequent tables, except for values obtained from the U. S. Bureau of Customs on imported seafood.

A breakdown of landings of types of seafood is given in Table 16. Of the 922 short tons of seafood landed anually at the time of this report, 747 tons (81%) were landed by American Virgin Islands fishermen. The value of the total annual landing was just under $1 million.

A comparison of total annual seafood landings by American Virgin Islands commercial fishermen in 1930 (Fiedler and Jarvis, 1932) and during 1967-1968 is given below:

DATE	ANNUAL FRESH SEAFOOD LANDING	VALUE
1930	616, 000 lbs.	$ 49, 080
1967-1968	1, 495,278 lbs.	781, 896

While the total catch increased about 150%, the value of the catch increased 1500%. Small wonder that most fishermen felt (Table 8) that the monetary return for the catch had increased!

A comparison of landings in the U. S. Virgin Islands by British Virgin Islands fishermen, in 1929 (Fiedler and Jarvis, 1932) and in 1967-1968, is given below:

DATE	ANNUAL FRESH SEAFOOD LANDING	VALUE
1929	13, 173 lbs.	$ 1, 102
1967-1968	326, 280 lbs.	$172,192

It can be seen that the British Virgin Islands fishermen have increased their share of the market in the American Virgin Islands, from about 2% at the time of the Fiedler and Jarvis study, to about 18% in 1967-1968; and this excludes any consideration of the fact that 36.4% of the St. Thomas fishermen in 1967-1968 were actually British Virgin Islanders by birth (Table 1).

Annual consumption of local seafood products by local commercial outlets is presented in Table 17, which shows that approximately 206 tons, valued at just over $240, 000, were used in this manner. This was approximately 22% of the landings.

A comparison of the 1967-1968 total landings and of commercial use is given in the table below. It is assumed that the balance was purchased by individual consumers.

PRODUCT	TOTAL LANDINGS (LBS.)	COMMERCIAL USE	
		Lbs.	% of landing
Fish	1, 672, 400	272, 494	16
Lobster	104, 540	97, 020	93
Conch	26, 860	19, 820	74
Whelk	22, 305	22, 305	100
Turtle	17, 160	600	3
Squid and Octopus	598	598	100
TOTAL	1, 843,863	412, 837	22

SURVEY OF COMMERCIAL FISHERY

The annual per capita consumption of local seafood in 1967-1968 was approximately 34 pounds; this figure excludes consideration of the approximately 750, 000 tourists, so the true figure is undoubtedly lower. This compares with 28 pounds per capita reported by Fiedler and Jarvis in their 1932 report.

Tables 18 and 19 represent 1967-1968 annual seafood products imports into St. Thomas 1/ and St. Croix (respectively), from Puerto Rico and the U. S. mainland. Table 20 presents 1967 imports into all American Virgin Islands of all foreign seafood products. Tables 21, 22 and 23 present a breakdown of the data given in Table 20.

A summarization, comparing all seafood imports (except canned goods) with local landings, appears in the table below:

PRODUCT	LOCAL LANDINGS	P. R. -U.S. IMPORTS	FOREIGN IMPORTS	TOTAL
Fish				
Lbs.	1, 672, 400	723, 171	485, 833	2, 881, 404
Value	$ 836,200	$ 524, 772	$ 155, 394	$ 1, 516, 366
Other Seafood				
Lbs.	171, 463	348, 245	28, 369	548 077
Value	$ 126, 810	$ 719, 069	$ 36, 936	$ 882, 815
Total Seafood				
Lbs.	1, 843, 863	1, 071, 416	514, 202	3, 429, 481
Value	$ 963,010	$ 1,243, 841	$ 192, 330	$ 2, 399, 181

Local landings accounted for more than half of the total fish consumption during the time of this survey, but for only about one-third of the other seafood used. Salted and smoked fish accounted for almost the entire amount of foreign fin-fish imports, while kingfish was the biggest single item imported from Puerto Rico and the U. S. mainland, accounting for about 40% of the fin-fish imported from those areas.

Shrimp accounted for almost 50% of the total "other seafood" imports, with lobster tails (and some whole lobster) and crab constituting 25% and 16% of this total, respectively. The local supply of shrimp and crab was virtually non- existent.

1/ Imports to St. John, which does not have a deep water port, generally go via St. Thomas and are included in the St. Thomas data.

SURVEY OF COMMERCIAL FISHERY

Local commercial fishermen were able to supply only slightly more than half of the total weight of the lobster and lobster tails consumed. However, if the weight of the lobster from which the tails came were considered, it is doubtful that local supply would have constituted more than one-fourth of the total amount used.

Table 24 indicates the types of preservation of fish purchased by commercial outlets in the American Virgin Islands in 1967-1968. The great majority of outlets purchased processed frozen fish from Puerto Rico and the U. S. mainland. Of those outlets purchasing local fish, two-thirds bought fish which had not been gutted, scaled or even iced, while the other one-third received fish gutted, but seldom scaled, and not iced. Some fishermen used ice for preservation during transportation of the catch, but removed the ice prior to sale of the fish, due to a prejudice on the part of many individual consumers against iced fish. While others may have followed similar practices, it was quite evident that the use of any ice is definitely the exception; only one outlet reported purchasing fish which had been iced.

Over two-thirds of the restaurants purchasing seafood indicated a willingness to pay higher prices for local fish if the fishermen would process and ice the catch (Table 25). However, as indicated previously, this seems of little importance since fishermen had no difficulty selling their catches at retail prices, without the additional handling or icing.

More than 70% of the restaurants and more than 60% of the groceries indicated a desire for additional local seafood (Table 26). This is to be expected, since local seafood is often requested by visitors to the islands and commercial outlets were receiving only a small part of the local catch.

Commercial outlet preferences for local seafood are listed in order, in Table 27. Red snapper, grouper, lobster, kingfish and potfish were the most desired items.

RECOMMENDATIONS

1. There is almost no control of fishing activities in the Virgin Islands. The local government should give serious consideration to the enactment of <u>enforceable</u> legislation providing for the regulation and protection of the fishery resources, for the upgrading of the fishery itself and for more modern and sanitary seafood handling practices. Particular emphasis should be placed on:

   A. Appointment of control officers to:

      (1) Control theft
      (2) Control pollution
      (3) Enforce conservation legislation
      (4) Regulate shipping routes
      (5) Maintain basic fishery statistics

B. Establishment of modern and sanitary marketing centers capable of handling fresh seafood and/or holding seafood for days or weeks, prior to sale.

C. Consumer education to dispel prejudices against iced and frozen fish.

D. Assistance to fishermen:

(1) Loans for up-grading the fishery.
(2) A cooperative outlet to provide gear at less expensive prices.
(3) Educational courses to acquaint fishermen with modern fishing gear and its uses, seamanship, boat mechanics and seafood handling practices.

2. Although the number of fishermen remains essentially the same as it was in 1930, and although the number of fish pots had declined about 50%,during the same period the catch has increased, indicating that the fishery stocks are not being endangered by overfishing, although the adverse effects of increasing pollution are becoming more and more evident. Bottom fishing activities, whether with pots or with hooks and lines, can probably be increased without endangering the fishery stocks.

3. Due to an almost complete absence of change in fish pot design in past decades, it cannot necessarily be concluded that this design is the best one. Investigation into the optimum design for a fish trap would seem to be worth-while, with studies of fish behavior (with respect to pots) and types of baits being conducted simultaneously and in conjunction with the design study.

4. Fishing with seines can undoubtedly be expanded; this would require the opening of beaches, both private and in National Park areas, to fishing activity. Seining does little damage to resident fauna, since migratory species are those normally harvested. Seining would also offer an interesting event for hotel or park visitors, and it could be regulated so that there would be no detraction from the scenic beauty of beach areas.

5. The demand for, and the limited effort required to catch, several species of deep-water snappers indicate that a fishery for these species has considerable potential and should be investigated.

6. The use of gill nets may be a profitable technique specifically for catching schooling jacks and mackerels, as well as for off-shore oceanic tuna, and merits closer study.

7. Multiple-line trolling is a successful fishery technique in other tropical areas, but has not been utilized in the Virgin Islands. The potential of this fishing method should be investigated.

8. Research on ciguatera, currently being conducted by the Virgin Islands Ecological Research Station, should be continued, with the ultimate goal determining a rapid and cheap test for individual fish. If and when such a test is feasible, the demand for non-ciguatoxic local fish can be expected to increase considerably.

9. The green turtle population has declined to the point of near extinction; this is due to inadequately enforced conservation practices. Illegal practices include the taking of unhatched eggs as well as the indiscriminate slaughter of females when they come up on the beaches to lay eggs.

10. Either the lobster population in the St. Thomas – St. John area is non-existent, the lobsters in these areas do not enter fish pots (as they do in other areas) or else fishermen did not report lobster catches from this locale. The actual reason should be determined.

CONC LUSION

The Virgin Islands fishery is characterized by lack of change and lack of desire for change, and, although the catch has increased, despite an apparently decreased effort, the demand for local seafood products can be expected to continue to exceed production, by ever-increasing amounts, unless changes take place.

Although there is a problem with ciguatera, research will hopefully overcome it. If proper attention is given to upgrading the present techniques, if more modern fishery techniques are utilized, if conservation practices are followed and if adequate government services and a good marketing system are established, the Virgin Islands fishery may be able to meet the demand for increased and safer seafood.

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SHORE LINE FISHING

INTRODUCTION

The Virgin Islands offer a great choice of fishing possibilities, from shoreline and inshore light tackle fishing to deep-sea trolling. Only a few years ago, there was also a chance to catch freshwater bass in some of the island ponds, but extended dry periods, land development and several other factors have led to the elimination of inland fishing on the islands.

For those wishing to fish from a boat, all types and sizes of craft are available. Arrangements can be made through most hotels or with the charter boat operators themselves, and information and advice are also available at the V. I. Department of Commerce, Office of Fishing and Water Sports. With very few exceptions, most of the St. Croix charter fleet is in Christiansted, whereas in St. Thomas boats may be chartered at Lagoon Fishing Center or Lagoon Marina on the east end, or at Yacht Haven in Charlotte Amalie. On St. John inquire in Cruz Bay or Coral Bay.

Small open outboard-powered boats can occasionally be rented from local fishermen, who can be contacted at the fish market in town, usually on Saturday morning. Visitors are urged to obtain the services of the boat owner or a guide, rather than attempt to navigate unfamiliar waters alone.

However, this report is intended primarily for use by the shoreline fisherman, who can expect as wide a variety in his catches as in the shoreline itself. Shoreline angling can yield barracuda, bonefish, crevalle, snapper, snook, tarpon, and a wide variety of other gamefish. If the visiting angler should catch a potential record size fish, he should contact the Office of Fishing and Water Sports or the marinas for assistance in registering the catch. There is always the likelihood of such a catch; there have already been many world record fish caught in Virgin Islands waters.

The American and British Virgin Islands together provide about 300 lineal miles of big game trolling water at the 100 fathom curve drop-off, and more than 500 miles of shoreline fishing.

There are hundreds of good shoreline fishing spots along the coasts of the U. S. Virgin Islands. Only the more readily accessible locations on the three largest islands have been listed. An attempt has been made to indicate the spots where the angler can fish at any time, without having to obtain permission. However, some locations where permission is required have been included and are so indicated. The adventurous fisherman can find many other shoreline areas in which to fish.

It should be pointed out that, while the Virgin Islands beaches are technically public property, the land access to much of the shoreline is privately owned. Generally, land owners will be found to be very friendly and cooperative, but it would be both courteous and wise to obtain permission before crossing private land.

It should be noted that some private property has been used as though it were public, due to "custom," for years or even decades. However, since these areas are private property, access can be terminated at any time.

Anglers should plan not to fish in public or private bathing beach areas, for obvious reasons. There is a multitude of other locations where the fishing is probably better anyway.

Those using the shoreline -- or any areas, for that matter -- should be sure to leave no litter or refuse. This practice will not only leave the area clean for those who follow, but is also a requirement set forth by private land-owners. Failure to clean up can result in the closing off of some fine fishing spots.

One additional note, to the visitor in particular. Learn to identify the manchineel tree and its fruit and then avoid them, especially after a rain; the manchineel is poisonous. The shoreline angler is also advised to avoid stepping on black sea urchins; while not poisonous, the spines can penetrate even rubber soled shoes, and are painful.

Accompanying maps show the locations of the various fishing spots. It is suggested that more detailed maps may be of interest. There are sets of detailed contour maps for each of the islands, prepared by the U. S. Geological Survey. These maps are available at Merrill's Apothecary, in Christiansted, or at the Paperback Gallery, in Charlotte Amalie. Although somewhat outdated (1958), the maps identify the various estates and geographical features, and also indicate reefs, coral heads and inshore water depths in considerable detail.

A short list of the most common species of fish is provided. Indications of preferred habitat are given for each species, and by noting these and the water conditions given for each locality on the maps, the angler can form some opinion about the probability of catching a given species at any specific location. Recommendations are made regarding tackle, but this is a very personalized aspect of fishing and many fishermen are now using ultra-light tackle on all species including the very large off-shore game species.

Generalized lure types are also given but a knowledgeable fisherman will adapt to the immediate conditions. For reef fish, bait of almost any sort will catch fish. Some of the more common items are: hermit crab, cut fish, whelk, conch, shrimp, live bait, worms and squid.

Most fishermen release all fish not intended for the table or the record book. Guides will tag released fish for you.

SHORELINE FISHING – ST. CROIX

1. SALT RIVER – EAST SHORE (JUDITH'S FANCY)

Location: West of Christiansted

Access: North Road west of Christiansted, to turnoff marked "Judith's Fancy"; keep on secondary road into Judith's Fancy. Owner-developer of this large estate has indicated a willingness to permit fishing from shore here, but requests that individual permission to do so be obtained from office. Office is in "ruins" beside old sugar mill and chimney, which will be clearly visible ahead and to the right, shortly after entering estate property.

Shoreline: What was once mangrove swamp has been dredged, filled and altered to produce an extensive land area with large marina basin and pool. Network of roads all along built-up shoreline.

Water: Bottom varies considerably, from sand to rock to coral patches to grassy areas, and is about 10 feet deep in the channel leading to basin, with shallow flats in other areas. Always quite calm.

2. JUDITH'S FANCY – NORTH POINT

Location and access: Same as #1.

Shoreline: Craggy and steep with little ground cover except grass.

Water: Bottom falls off sharply, with large outcroppings above surface of water. Live coral on bottom. Usually quite rough.

3. JUDITH'S FANCY – EA STERN SHORE

Location and access: Same as #1.

Shoreline: Basically low "beach rock" formations, with only a few sandy beach spots. Exposed shore with little ground cover.

Water: Bottom has very shallow slope, and is composed almost entirely of low ledges covered with short algal growth. Frequently very rough here.

4. "PELICAN COVE" AT LA GRANDE PRINCESS

Location: West of Christiansted, north shore.

Access: La Grande Princess turnoff (may have a "Pelican Cove" or "Queen's Quarters Beach" sign at main North Road), straight to beach. Beach club immediately to east and private beaches to west.

Shoreline: Small sandy beach area.

Water: Fairly shallow out to a terminal portion of Long Reef, through which, at this spot, a narrow channel was blasted some years ago. Bottom covering is eel grass and sand patches, with some rocks and coral. Generally calm, but apt to be rough from northerly swells in wintertime.

5. CHRISTIANSTED HARBOR – GOLDEN ROCK

Location: West of Christiansted.

Access: Turn at Vitraco Mall. Road goes straight to beach.

Shoreline: Narrow, coarse sand beach to west. Barge aground on point just to east.

Water: Sand bottom, with grass growing close inshore. Some coral patches 40 to 50 feet off shore. Very calm and shallow.

6. CHRISTIANSTED HARBOR – WE STERN SHORE OF CHRISTIANSTED TOWN

Location: Adjacent to housing projects at northwest corner of Christiansted.

Access: From West Lane or through housing projects.

Shoreline: 3/4 mile long, very wide sand beach, resulting from dredging operation. No trees.

Water: Bottom slopes gently to depths of 5 to 6 feet, several hundred feet from shore, and is plain sand, with a few grass patches. Area frequently used for swimming, especially on weekends. Usually calm.

7. CHRISTIANSTED HARBOR – PUBLIC WHARF

Location: Opposite Protestant Cay.

Access: Center of Christiansted.

Shoreline: Concrete bulkheaded wharf.

Water: Sand and grass bottom. Depth 6 to 10 feet at wharf. Usually murky, occasionally with large weed patches on surface at wharf. Fairly calm except at times of strong winds from east or northeast. Boats frequently tied up at wharf in daytime.

8. CHRISTIANSTED HARBOR - WEST SIDE OF PENINSULA SEPARATING HARBOR FROM A LTONA LAGOON

Location: Northeast of Christiansted.

Access: Shoreline dirt road leading north from freight dock at Gallows Bay.

Shoreline: Narrow, sandy beach about 1/2 mile long. Grass and a few trees.

Water: Protective reef 5 to 30 feet offshore along northern portion of beach. Shallow inside reef (3 feet) and bottom mainly sandy. Depth outside reef 3 to 4 feet; bottom grassy and sloping gently downward. Usually calm.

9. ALTONA LAGOON - WESTERN END

Location: Northeast of Christiansted.

Access: Same as #8. Supplementary footpaths along edge of lagoon.

Shoreline: Predominantly mangrove trees, with some gravel and sand beaches.

Water: Connected to Christiansted Harbor by narrow bridge channel at southwest corner of lagoon. Some sand shelves along shoreline, but generally drops off abruptly to depth of several feet. Maximum depth: 13 feet. Bottom generally grassy. Always calm.

10. FORT LOUISE AUGUSTA BEACH

Location: East of radio tower, northeast of Christiansted.

Access: Via lagoon peninsula road (see #8). Short steep footpath from end of road.

Shoreline: Sand beach 1/4 mile long. Some sea grape trees and shrubbery. Rocky points at both ends.

Water: Sandy bottom immediately adjacent to shore. Grassy bottom begins abruptly in about 4 feet of water. Large coral reef to east.

11. BEAUREGARD BAY

Location: West of Buccaneer Hotel, east of Christiansted.

Access: Private property. Permission to use this area can only be granted by and at the discretion of Bucaneer Hotel; check at hotel desk. Usage fee can be expected if permission is granted.

Shoreline: Magnificent sand beach, 1/2 mile long.

Water: Generally continuous reef ledge just offshore. Bottom otherwise sandy with grass patches. Occasionally rough.

12. BAY EAST OF SHOY POINT

Location: Part of Bucaneer Hotel property.

Access: Through Buccaneer Hotel road. Private property; check at hotel for permission. Usage fee can be expected if permission is obtained.

Shoreline: Small cove with sandy/rocky beach at center and rocky points at both ends.

Water: Scattered coral patches on sandy bottom of beach, with solid coral shelves on either side. Usually not calm.

13. TAMARIND REEF

Location: North shore, east of Christiansted.

Access: Turn onto dirt road at Tamarind Reef Hotel sign on main road. Hotel management has indicated a willingness to grant permission to fish from the sea shoreline, if inquiry is made, but fishing in Southgate Pond is specifically prohibited.

Shoreline: Coral and limestone, with several small rock jetties.

Water: Bottom drops off immediately to depths of 6 to 12 feet and is covered with various types of coral. Usually not calm.

14. CHENAY BAY ("TIDE BEACH")

Location: North shore, east of Christiansted.

Access: Dirt road leading north from paved road (barbed wire fence on either side). This beach is used by residents of Tide Village.

Shoreline: Wide sandy beach with sparse, scrubby vegetation to west. Eastern shore is gravel, leading to rocky point.

Water: Small reef ledge runs adjacent to most of shore. Bottom almost entirely covered with grass; slope very gentle. Large coral reef off eastern point. Usually quite calm.

15. WEST OF POW POINT

Location: North shore, east of Christiansted.

Access: Main paved road has two turn-off parking areas. Shore is reached by descending short steep slope on foot.

Shoreline: Narrow beach is predominantly sand, with some rocky patches.

Water: Rather shallow; covered with coral and other snags to west. Eastern portion sandy, with less coral, but is private property for use by home owners there. Usually fairly calm.

16. BUCK ISLAND

Location: Off northeast coast of St. Croix. National Park area.

Access: Normally aboard one of many regularly scheduled boats sailing to Buck Island for the day, every day. Fishing (no spear fishing) permitted on western end of island. Shore signs clearly indicate limits of fishing area.

Shoreline: Western shore sandy, with some rocky areas near eastern limits of fishing area. Trees along most of beach. Rest room facilities and picnic tables at center of southern shore.

Water: Varies considerably, but basically sand bottom on south and west, with some coral ledges at south center. Northwestern area has coral offshore. Water usually clear and fairly calm.

17. FISHERMA N'S PLOT AT KNIGHT'S BAY (SMUGGLER'S COVE)

Location: North shore, east end, just east of turnoff to Grapetree Bay. There may or may not be an identifying sign indicating "Fisherman's Plot."

Access: Entrance about 50 yards east of stone pillars at "Smuggler's Cove" entrance. Dirt road leads down to the beach.

Shoreline: Although a fence would seem to indicate otherwise, there is a sizable sandy public beach here, set aside for fishermen, beginning at small rocky bluff to east and extending 250 feet west. Beach is fine sand and there is a small grove of tall trees at shore end of access road. Shore to east is rocky, and walking is difficult.

Water: Shallow for a considerable distance from shore. Bottom is basically grass-covered, but rough, with scattered coral heads and pieces of broken coral. Water off eastern shore to point is full of coral reefs. Offlying fringe reef provides calm waters inshore.

18. BAY EAST OF COTTONGARDEN POINT

Location: North shore, east end.

Access: Main north road changes from pavement to dirt after passing Cramer's Park at Cottongarden Bay. Two access roads lead off main dirt road; one at west, just after descending road over hill at Cotton garden Point (this access road is apt to be slippery, and almost impassable in a two wheel drive car, after a rain); the other is just before crest of next hill, at east end of bay.

Shoreline: Generally sandy and passable from one end to the other, although there is a small rocky point at the center. Shore backed by scrub and numerous trees, many of which are poisonous manchineel.

Water: West of central rocky point, there is a limestone ledge along most of water's edge. Scattered large coral patches offshore. Bottom of eastern portion of bay is covered with extensive coral growths, although there is also much grass. Relatively shallow in eastern half of bay (2 to 6 feet), whereas to west it is generally somewhat deeper. Off rocky eastern point, there is a deep (15 to 20 feet) channel in the coral, about 40 feet from shore; current can be extremely strong here. Usually calm.

19. "BLUE GUT"

Location: Last bay on north shore at east end of island.

Access: Two dirt turnoffs; one at crest of hill at west end of bay, and one at east end of bay. Both are steep and can be treacherous; be careful! It may be preferable to park on edge of main road.

Shoreline: "Upheavel type" ledge along much of shore, with some sand separating ledge from water's edge. Shore at both ends of bay extremely rocky and best looked at but not traversed. Some trees and scrub behind beach section, but much of this is manchineel.

Water: Inshore ledge parallels shore a short distance out. Eastern end of bay full of various coral types, while western section predominantly grass, with only a few coral heads. Depth 3 to 4 feet adjacent to ledge. Maximum depth 6 to 8 feet before reaching coral barrier reef not too far from shore. Sizable waves often crash on offshore reef; usually not as calm as other portions of northeastern shore.

20. EAST POINT ("EAST END")

Location: Most easterly land under the U.S. Flag.

Access: Dirt road to turning circle atop hill at East End usually rough and rocky, as well as dusty. To fish from shore, a descent of more than 250 feet is required on foot, and although there are "paths" down, it is fully as far down and back up as it looks. Recommended for youthful anglers.

Shoreline: Very sharp rocks, no vegetation. A few small level places to stand.

Water: Sharp drop-off to depths of 15 to 20 feet, at face of rocks. Scattered coral heads cover much of bottom. Completely open exposure results in very rough water most of the time, but anglers can usually stay high enough above water to remain dry.

21. EAST END BAY (ALSO CALLED 'WINDWARD BAY")

Location: Most easterly bay on south shore.

Access: Long and fairly steep road down, turnoff being just west of East End turning circle. Road not always passable, except soon after road grading. Loa walk down.

Shoreline: Beautiful sandy beach, 1/4 mile long. Low grassy dunes; no vegetation. Rocky headlands at either end.

Water: Wide coral reef almost to shoreline along entire beach. Usually strong surf breaking over reef.

22. ISAAC BAY

Location: Just west of East End Bay, south shore.

Access: Cannot be reached by car. Footpath over headland at Point Cudejarre or from Jack Bay (see #23). Long walk either way.

Shoreline: Very much like East End Bay, only larger.

Water: Similar to East End Bay, but apt to be calmer.

23. JACK BAY

Location: East end of island, south shore, between Isaac Bay and Grapetree Bay.

Access: Limited to guests of Grapetree Bay Hotel. Easiest access by footpath from end of Grapetree Bay Hotel Road, but can also be reached on foot from Isaac Bay, over headland.

Shoreline: Beautiful beach of fine sand, backed by trees at foot of hills.

Water: Extensive coral growth at western end, and large grassy area in center and towards east. Isaac Point and offshore barrier reef give fair protection from sea, particularly at east end of bay.

24. FISHERMAN'S PLOT AT GRAPETREE BAY

Location: Just west of *Grapetree* Bay Hotel entrance, south shore. Identifying sign probably not up.

Access: Although this is a public beach with unlimited public access, entrance has been obscured as homeowners on both sides have covered shore access road with rubbish. Access road appears to be driveway of Logan home (no. 3), and in fact goes right by west side of house; Baldwin home is to west of entrance. It is possible to drive only part way down, unless road has since been cleared.

Shoreline: Beautiful sandy beach. Western end of plot begins where rocky cliff and beach meet. Plot extends 250 feet eastward and is 50 feet wide. Almost no ground cover.

Water: Bottom has moderate slope, and is primarily sand, with some grass and coral patches. Dredging operation to east has caused water to become turbid, and bottom topography may alter. Apt to be fairly rough at times.

25. FISHERMAN'S PLOT AT TURNER HOLE

Location: Northeast of Beach Hotel, east end, south shore. Identifying sign may or may not be in place.

Access: Very short, fairly steep dirt road to beach. Parking by main road advisable. Access road should be readily visible.

Shoreline: White sand beach.

Water: Bottom sand and grass; gradual slope. Dredging immediately to west may alter bottom and shoreline configurations. Water turbid and fairly calm.

26. <u>GRASS ("GRASSY") POINT</u>

Location: South shore, towards east end, between Rod Bay and Turner Hole.

Access: Dirt road turnoff from south shore roads leads directly to top of Grassy Point.

Shoreline: Grassy Point is a rocky hill, rising from a low saddle of land to an elevation of 45 feet. Ground cover mostly grass, as the name implies. To east and south, shoreline craggy and steep. Gravel beach to west, accessible from saddle.

Water: To east and south, bottom drops off sharply to depths of 10 to 20 feet, where bottom consists of coral, rocks and sand. Since these two sides are completely exposed, water usually quite rough here. Western side, however, is met by the beginning of a barrier reef, where bottom is chiefly the reef itself, with some sand in shallower water near the lower land area; water calmer here.

27. <u>ROD BAY</u>

Location: Immediately West of Grassy Point, south shore, towards east end.

Access: Two dirt roads; one to east, near Grassy Point road, and one about 1/2 mile west. Grassy Point road itself also gives access to eastern end of Rod Bay.

Shoreline: Generally rocky, with some gravel areas, mostly to west. Ground cover to east is sparse and scrubby. Some trees at end of west access road.

Water: Inside offshore barrier reef, bottom almost entirely sand, with only a few isolated coral patches. Depth in bay 6 to 8 feet. Almost always calm.

28. ROBIN BAY

Location: East of Great Pond, south shore, towards east end.

Access: Two dirt roads, leading from south shore road (also dirt here). Both turnoffs are through barbed-wire gates, which are usually open. If gates are closed, do not enter. Eastern access leads to small point at center of bay. Western turn-off goes over the usually small salt pond. Latter very muddy when wet.

Shoreline: Eastern shore generally stony, while western portion has a narrow coarse beach. Some scrub and a few trees, primarily to west.

Water: Bottom to east is grass and sand, with some coral patches; some rock outcroppings not far from shore. Western portion of bay is basically a "grass flat," with only sparse and isolated coral growths. Maximum depth about 6 feet. Calm.

29. GREAT POND BAY

Location: South shore, towards east end, southeast of Christiansted.

Access: Best route is southern turnoff (at Southgate) from north shore road, east of Christiansted. Road paved to Great Pond. Eastern portion of Great Pond Bay private property, used by Boy Scouts. At turn in south shore road closest to sea, there is a new cyclone-type fence; public access to center and western by shores is through gate here.

Shoreline: Very low sandy beach, with scrub growth behind beach at center. Grass grows almost to water's edge to west.

Water: Bottom sand and mud, with grass covering. Fairly shallow and protected. Local open fishing boats moor here.

30. GREAT POND

Location: Inland from Great Pond Bay (#29).

Access: Short road turnoff from eastern edge of pond.

Shoreline: Very low and flat; no vegetation. Apt to be soft and very slippery after rain. Small narrow channel connects with sea, at southeast corner.

Water: Generally hard crust on bottom, but apt to be very soft underneath. Extremely shallow; no bottom cover.

31. POINT AT WEST END OF CANE GARDEN BAY

Location: South shore, center of island, just east of Hess Oil Plant.

Access: Continue straight south on dirt road where Centerline roads turns at bottom of hill at Peters Rest. Take first main dirt road going west, go over hill and then take first dirt road turnoff to south. Leads directly down to point and to Limetree Bay.

Shoreline: Low (5 to 15 feet) sandstone cliffs. Exposed shore; small amount of scrub growth.

Water: Hard sandstone bottom to west, with sand and grass cover. Coral finger reef off point. Due to shore exposure, wave action seldom ceases.

32. LIMETREE BAY

Location: Immediately adjacent to and east of eastern Hess breakwater.

Access: Same as #31.

Shoreline: Coarse, dark-sand beach. Some low trees and scrub.

Water: Very shallow, wide sand and "grass flat" shelf. Sand pockets and deeper sandy bottom offshore. Water inshore generally protected and calm, but deeper water off shelf frequently choppy and murky. Many small open boats moored here.

33. MANNING BAY

Location: South shore, southeast of airport.

Access: Two access roads actually join along shoreline but western access is easiest to find; it is a turnoff immediately east of race track, across from airport.

Shoreline: Immediately west of public "dump." Sandy beach rather cluttered with trash and debris. Mangroves, manchineel and scrub behind beach. A "gut," which used to be open to sea, is now dammed up and there is a long, narrow, stagnant pool inland a short distance.

Water: Shallow and extremely turbid and dirty. Wading and swimming not advisable. Bottom mud and sand, with general grass cover. Sand bars offshore. Local open fishing boats moored in lee of small point.

34. SOUTHWEST CAPE = SANDY POINT AREA (entire area is known locally as "SANDY POINT")

Location: Southwest end of St. Croix, south of Frederiksted.

Access: (1) South shore of Sandy Point - Southwest Cape area is best reached by following main road leading south out of Frederiksted, past Post Office, and continuing straight onto dirt road (instead of turning left onto Centerline Road). At end of this road, turn west on dirt road, which goes almost all the way to end of point, with access to south shore being on any of numerous side roads to the left (i.e., south). Short walk from end of road to western shore. 25 or 30 feet before end of this access road, turnoff to north leads directly to Sandy Point proper and to beach running towards town.

(2) North, or Frederiksted, side of Sandy Point area can also be reached by taking shore road south from fish market, at southwest corner of town. Road runs between seashore and landlocked salt pond and extends only as far as public beach facilities which are about half-way between fish market and Sandy Point proper.

Shoreline: South shore of this area is generally narrow and sandy, usually covered with washed-up weeds and flotsam. Area from Southwest Cape to Sandy Point is a pure sand beach which varies considerably in contour, depending upon storms and wave action. Frederiksted side of point is a wide but rather sharply sloped sand beach. Ledges and outcroppings usually exposed. Scrub trees and small wild orchids cover much of the inland area.

Water: Bottom off south side of peninsula generally grass-covered, with some coral growth and ledges. Sand patches occur further from shore. Bottom slopes off sharply to several feet, at shoreline, and more gently thereafter. Bottom immediately offshore at Southwest Cape is a mixture of coral ledges, grass, and sand. There is usually a meeting of waves from south and west, at Cape, and water is seldom totally calm. Bottom configuration along shore between Cape and Sandy Point varies with weather, but is basically pure sand, with coral heads beyond casting distance from shore. Water here varies from dead calm to high surf, depending on weather. Beginning at Sandy Point and proceeding towards Frederiksted, bottom is basically sand with isolated coral heads becoming more frequent towards town. Ledge of varying dimensions extends along this entire coast, broken only here and there by small sandy accesses to water. Water along this portion of coast apt to be calm, but heavy surf not infrequent.

35. FREDERIKSTED TO SALT POND

Location: Western shore, south of Frederiksted.

Access: Shoreline road south from fish market, at southwest corner of town.

Shoreline: Varied, but generally fairly rocky, with only a few sandy areas on shore. Some trees border road. Several houses and an oil storage depot along shore. Permission to fish near latter can usually be obtained upon request. Shore south of oil tank area is all private property. Shore north of depot is not.

Water: Rough bottom south of oil depot is a network of ledges and coral. Most of bottom covering to north is grass, but there are some sandy patches. Water usually fairly calm, although not always clear.

36. PIER AT FREDERIKSTED

Location: Wharf area, Frederiksted.

Access: Check with guard on duty at pier entrance, concerning permission to fish from pier. Fishing not permitted when ships are unloading.

Water: Rip-rap on bottom along access to main unloading area. Otherwise sand, with grass patches. Depth up to 40 feet. Usually fairly calm.

37. FREDERIKSTED PUBLIC BEACH

Location: Immediately north of Fort Frederik.

Access: Path from paved road, just north of small bridge beside tennis courts.

Shoreline: Sand and rock beach. Flat grassy area between shore and road.

Water: Very rough bottom close to shore, gradually **sloping** from shore. Covered with stones, broken coral and assorted objects. Large ledges, rocks and some sand patches further out, in 6 to 8 feet of water. Sewage outfall just around point to south. Usually calm here.

38. SHORELINE AT ESTATE WILLIAM

Location: Western shore, north of Frederiksted.

Access: Shoreline road, north from Frederiksted. Short turnoff under large trees, immediately north of small stone house (third building north of sharp curve in road).

Shoreline: Sand beach close to road. A few trees, but mostly scrub growth.

Water: Bottom mostly sand and grass, but extent of sand covering over hard bottom varies with weather. Series of small ledges and sparse coral growth 50 to 75 feet from shore in 6-8 feet of water. Usually calm.

39. NORTH END OF SPRAT HALL BEACH

Location: North of Frederiksted; opposite Crique Dam Road.

Access: Shoreline Road, north from Frederiksted; there is a beach and restaurant facility, clearly marked "Sprat Hall Beach." Owners will allow fishing from shore, north of fenced area, but it is suggested that individuals obtain permission. Inquire at beach facility, or at Sprat Hall Hotel, which is atop hill on inland side of road about 1/4 mile north of beach.

Shoreline: Sandy, palm-lined beach, with some other trees.

Water: Bottom here is a series of weed-covered ledges, paralleling shore, and progressing seaward for 75 to 100 feet, where sand patches begin. Fairly shallow inshore and generally rather calm.

40. SHORE SOUTH OF BUTLER BAY

Location: Western shore, north of Frederiksted.

Access: Shoreline road, north from Frederiksted, beyond sharp curve north of Tracking Station.

Shoreline: One or two small sand/gravel beach areas, but chiefly eroded "beach rock" shore, with large trees along road, behind shore.

Water: Bottom rough, with many ledges, coral heads and other snags. 4 to 8 feet deep at shore, except at beach points, and bottom falls off rapidly a short distance from shore. Wave action variable.

4L NORTH OF BUTLER BAY

Location: Western shore, north of Frederiksted.

Access: Shoreline road, north from Frederiksted, beyond cabana at Butler Bay. Park along road.

Shoreline: Almost entirely eroded "beach rock," with some sand further inshore. Trees along top of steep roadside bank.

Water: Bottom drops off sharply to varying depths, right at shoreline, and there are large caves, ledges and coral heads set in sandy areas and grass patches. Water fairly calm most of the time.

42. HAM BAY

Location: Northwest corner of island.

Access: Turnoff parking area at end of paved shoreline road, north from Frederiksted.

Shoreline: Predominantly stony beach, with some sand ledges at edge of shore. Trees between shore and road.

Water: Generally hard bottom, smooth in some areas but covered with stones or dead coral pieces in others. Live coral further from shore and at either end of bay. Some sandy patches. Gradual slope from shore. Always some wave action.

43. HAM BLUFF

Location: Northwest corner of island; site of Coast Guard Station.

Access: Shoreline road, north from Frederiksted. Turn left at end of paved road, through Clover Crest Hotel entrance pillars at Ham Bay, and stay to left, along shore. Several turnoffs from this dirt road, between hotel and Coast Guard Station. Last turnoff before going around a corner and up a small hill gives access to bluff to east, to bay next to bluff and to shore west of bay.

Shoreline: Very rough and rocky at base of bluff, which can be reached by walking over bay beach. Sheer cliff behind. Bay has stone and broken eroded "beach rock." Some scrub along western shoreline, by road.

Water: Bottom drops off very sharply at base of bluff, to depths of 20 to 30 feet in some places. Bottom is a rapidly sloping continuation of bluff and is mostly huge rocks and coral growth. Bay bottom studded with coral heads. Water west of bay 15 to 20 feet deep at shoreline. Bottom fairly flat and chiefly sand, with many coral heads. Surf in entire area apt to be very high and fishermen are urged to exercise care not to get knocked down and washed into sea at such times. Seldom totally calm.

44. WEST OF NORTH STAR

Location: North shore, west of Christiansted.

Access: Shoreline road running from Salt River to Davis Bay. Park along roadside.

Shoreline: Generally sandy beach, short bank up to tree-lined road.

Water: Bottom sandy and fairly flat. Sea generally fair to rough.

45. EAST OF NORTH STAR

Location and access: Same as #44. One of two turnoffs.

Shoreline: Narrow sandy beach about 30 feet from road, with trees between.

Water: Shallow close to shore. Bottom fairly flat; sand patches interspersed with grass-covered hard bottom areas. Live coral patches 100 feet offshore.

46. OPPOSITE LA VALLEE SCHOOL

Location and accesses: Same as #44. Very short turnoff visible, just east of La Vallee School on north shore road.

Shoreline: To east, a narrow sand and coral beach, several hundred yards long. At access and to west, predominantly eroded "beach rock," with one beach area full of rock outcroppings.

Water: To east, shallow sloping bottom has scattered coral patches and heads. At access and to west, bottom generally drops off sharply at shoreline and slopes rapidly from there; sand and coral. Apt to be very rough, especially in winter months.

47. WEST OF RUST-OP-TWIST

Location and access: Same as #44. Three short turnoffs.

Shoreline: Trees border road, which is not far from shore. Sand beach.

Water: Shallow sand and grass flats inside protective reef, calm.

48. EAST OF RUST-OP-TWIST

Location and access: Same as #44. West of Baron Bluff. Two access turnoffs.

Shoreline: To east shallow and rough; coral and rocks. To west bottom deeper close inshore, with some coral in a generally sandy area. Seldom calm.

49. EAST OF BARON BLUFF

Location: North shore road, just east of Baron Bluff.

Access: Two access roads, each occurring west of a sharp inland curve in road. Both clearly visible, but due to slope may be impassable after rain. Steep descent to shore on foot.

Shoreline: Both "beaches" mostly rocks, gravel or broken coral backed and separated by rocky—and sometimes steep—points or bluffs.

Water: Bottom slope close to shore fairly gradual, but boulders, rock outcroppings and coral make this a difficult fishing spot. Water usually fairly rough to extremely rough.

50. SUGAR BAY ESTATES

Location: North shore, just west of Salt River.

Access: Turnoff from Salt River Road clearly marked. Follow to sea.

Shoreline: Narrow sand beach. Rocky point to east. Grove of trees behind beach to west.

Water: Protected by an almost solid offshore reef. Close inshore, bottom shallow and almost entirely covered with turtle grass, with a few rocks. To west and closer to inshore side of reef, bottom more predominantly sand, with live coral heads and a few grass patches. Usually quite calm.

51. SALT RIVER – WEST SHORE

Location: West of Christiansted.

Access: Salt River Road, from bottom (west side) of Morningstar Hill. One small clearing between road and shore.

Shoreline: Small gravel-dirt beach with mangroves on both sides.

Water: Bottom muddy, with some weeds and refuse. Water always calm, but murky.

SHORELINE FISHING - ST. JOHN

1. CRUZ BAY

Location: Cruz Bay Harbor and "Creek" at the village of Cruz Bay, west end of island.

Access: All roads on St. John lead to village. Ferry boat from St. Thomas docks there. In addition, seaplane flights from St. Thomas and St. Croix land there. Entire area open to public.

Shoreline: Harbor is surrounded by sandy beach backed by sea grape, coconut palm and seaside mahoe trees. It is separated from "Creek" by rocky headland which is site of administrator's house and government offices. Head of "Creek" is completely bulkheaded and is site of Virgin Islands National Park Headquarters.

Water: Harbor has sandy bottom covered with turtle grass. "Creek" is largely without vegetation, and bottom is muddy. Both areas extensively used by boats as mooring and docking sites. Harbor sometimes has ground seas during winter. "Creek" always very quiet.

2. HONEYMOON BEACH #1

Location: Between Cruz Bay and Caneel Bay Hotel.

Access: Secluded sandy beach accessible by steep footpath from Lind Point housing area above Cruz Bay village. Within National Park, but northern end of beach privately owned and adjoins a residence.

Shoreline: Sand beach with coconut palms and typical beach vegetation.

Water: Gently sloping bottom with turtle grass and small coral heads. Sometimes in winter there are rather heavy ground seas.

3. HAWKNEST BEACH

Location: North shore beyond Caneel Bay Hotel.

Access: Take north shore road from Cruz Bay. Drive past entrance to Caneel Bay Hotel and over steep switch-back. At bottom, National Park Service signs indicate area.

Shoreline: Broad, sandy and flat, with many shade trees and picnic facilities including restrooms. This is a National Park Service "Day Use Facility."

Water: Sloping sandy and/or beach rock shore with extensive reef areas mixed with turtle grass flats.

SHORELINE FISHING - ST. JOHN

4. TRUNK BAY

Location and Access: North Shore road from Cruz Bay past Caneel Bay and Hawknest. Turn left from paved road at National Park Service sign.

Shoreline: Broad, flat and sandy, with many shade trees and complete facilities, including picnic shelters, toilets, showers, change-rooms, lunch counter and life guards. The most popular and famous recreation beach on St. John. Beach is white sand with rocky crags at each end.

Water: Clean white sand extends offshore as far as one can cast. Reef areas near small cay and at either end of bay.

5. CINNAMON BAY CAMPGROUND

Location and access: North shore road from Cruz Bay past Caneel, Hawknest and Trunk Bay. Turn left off main road, at Park Service sign.

Shoreline: The only campground in Virgin Islands National Park. Offers both tents and cottage facilities, with small commissary for supplies. Campsites are ona broad sandy flat, covered with coconut palms and large shade trees. White sand beach with rocky headlands at either end.

Water: Gently sloping bottom which becomes a turtle grass flat. Reefs near the commissary building and at either end of beach. Very heavy ground swells during winter.

6. MAHO BAY

Location and Access: North Shore Road to end of paving. Continue over dirt road to bottom of steep rocky hill. First bit of beach on left is privately owned. Two small houses behind wall are National Park Service residence and beach to east of them is privately owned, but the owner, who lives in the old stone building at the eastern end, sometimes gives permission to use it.

Shoreline: Flat and sandy, with palms and seaside mahoe. Rocky outcrops on either end.

Water: Turtle grass bottom. Usually very calm.

7. FRANCIS BAY

Location: Far north side.

Access: From Cruz Bay via North Shore Road, or better, Centerline Road past Reef Bay trail and road to Bordeaux. Take first left turn after Bordeaux junction. Dirt road descends steeply to signs which indicate Annaberg ruins. Turn left beyond old cobblestone road. Most of road from this point is privately owned. At gate is a footpath to beach. Considered by Park Service to be "boating beach" and there are often several yachts moored off beach.

Shoreline: Large flat area with shade trees and picnic facilities. Long white beach backed by typical tall shoreline vegetation. Southern-most tip of beach privately owned. Northern end a rocky headland.

Water: Bottom slopes from beach to offshore turtle grass bed, with very little coral or other growth. Usually very calm, but sometimes a surge during the winter months.

8. MARY CREEK

Location: Far north shore.

Access: Same as #7, except stop before taking last left-hand turn.

Shoreline: Low and flat, rimmed with **small mangrove** trees intermixed with some poisonous manchineel trees.

Water: Shallow, protected inlet, with turtle grass, muddy bottom, coral heads and reef along edges.

9. ANNABERG FLAT

Location and Access: Same as #8, except turn right and continue to picnic table and parking area.

Shoreline: Flat and open, with few trees at water's edge. Small gently sloping picnic area behind. Some shade trees.

Water: Extensive shallow flat covered with sand, turtle grass and "deadman's fingers" coral. Much of flat is uncovered or very shallow at low tides. Outer edge fringed by well-developed coral reef.

10. HAULOVER BAY

Location: East of Coral Bay village.

Access: Centerline Road from Cruz Bay to Coral Bay. Take left hand road below Moravian Church and continue toward East End on level dirt road at sea level. Continue past Park Service boundary sign, and park at bottom of steep upgrade. Footpath from road on left leads to cobblestone beach on north shore, about 200 yards away.

Shoreline: Heavy vegetation bordering a steep black cobblestone beach. Footpath on right leads to several miles of varied shoreline, with small secluded beaches and bays where there are very few visitors.

Water: Steeply sloping bottom with well-developed coral heads and reef areas. Heavy surge very common.

11. EAST END BEACHES

Location: East End beyond Haulover.

Access: Same as #10, except continue on. Shoreline and beaches on right. Virtually entire shoreline is privately owned, but permission may be requested and usually will be granted for fishermen. Road dead ends at private property.

Shoreline: Variable from sandy beaches rimmed with shade trees to rocky outcrops covered with cactus and century plants.

Water: Gently sloping sandy bottom, steep drop-offs and coral reefs.

12. CREEK AT HURRICANE HOLE

Location: Hurricane Hole.

Access: Same as #10, except stop at water's edge after passing first cluster of houses beyond Coral Bay village.

Shoreline: Low and flat at roadside, steep around edges of "creek." Several creeks"accessible by foot. Shoreline is within Park Service jurisdiction; water is not. Banks are steep and overgrown with bush, small trees and mangrove at water's edge.

Water: Deep at "creek" centers, with sandy bottoms. Coral and reef organisms slightly developed on southern shorelines; mud on northern shores and upper ends of "creeks. "Always very calm; completely protected from all but most violent storms.

13. HURRICANE HOLE

Location: Part of Coral Bay, beyond Coral Bay Village.

Access: Same as #12.

Shoreline: Open and mostly flat, with mangroves and other small vegetation between road and water.

Water: Slopes off into deep water, with turtle grass bottom and scattered coral patches. Water is outside National Park, but shoreline is within Park.

14. CORAL BAY

Location and Access: Centerline Road from Cruz Bay. Turn right just across from Moravian Church.

Shoreline: Mostly flat; varies from mud flat to grassy banks to large mangrove trees. Road adjacent to water's edge, around most of bay. Small piers at village and at Calabash Boom on west shore. Cold drinks and food available at several locations.

Water: Much of the near shore water is very shallow and wadable. Sometimes choppy.

15. DRUNK BAY

Location: South shore.

Access: Take right-hand fork of road below Moravian Church in Coral Bay. Drive past Calabash Boom and John's Folly to Park Service sign indicating "Salt Pond Bay." Take footpath to beach and follow marked trail, left from beach.

Shoreline: Barren, steep and covered with large boulders. Directly exposed to open sea and trade winds. Beachcomber's paradise.

Water: Rough, often wildly so, with rocks and reefs but open to sea and providing the only route around Ram Head for fish.

16. RAM HEAD BAY

Location: South shore.

Access: Same as #15, except take right-hand footpath at south end of beach. Continue along west shore of Ram Head.

SHORELINE FISHING - ST. JOHN

Shoreline: Steep and rocky, with cobblestone beaches between rock outcrops.

Water: Steeply sloping bottom, with rocks and coral heads, patch reefs and deep holes. Usually fairly quiet, but sometimes with heavy surge.

17. SALT POND BAY

Location and Access: Same as #15, except stop at beach.

Shoreline: Sandy beach, with rocky shores at each end. Sea grape and mahoe for shade. Rocky shore with low brush, cactus and century plants.

Water: Gently sloping bottom with turtle grass cover. Reefs on either end. Almost always very calm.

18. GREATER LAMESHUR BAY

Location: South shore.

Access: Same as #15, except continue on main road (requires 4 wheel drive vehicle) to very steep upgrade. At bottom of very steep downgrade continue for about 200 yards and watch for opening to beach on left.

Shoreline: Cobblestone beachbacked by heavybrush, mangroves and trees.

Water: Bottom slopes rapidly into rather large bay. Small coral patches submerged and scattered in turtle grass. Usually calm.

19. LESSER LAMESHUR BAY

Location and Access: Same as #18, except continue past road to Greater Lameshur Bay (on left), Virgin Islands Ecological Research Station fisheries laboratory and dock (on left), to parking area at white sand beach.

Shoreline: Flat, sandy, with grass, shade trees, picnic tables and toilet facilities. White sand beach with rocky shoreline at each end. Site of Virgin Islands National Park Ranger Station and residence. Offices at west end of beach and residence at top of hill behind beach.

Water: Very gently sloping bottom, from beach to turtle grass patches. Reefs and rocks at each end of beach. Occasional surge, but usually calm.

20. REEF BAY

Location: Middle of south shore.

Access: Same as #19 except walk 2 1/2 miles from Lameshur Ranger Station, or take Centerline Road from Cruz Bay to head of Reef Bay Trail. Park Service sign on right-hand side of road, at bottom of steep downgrade, just beyond Reef Bay overlook. A mile (one way) walk down a heavily shaded but steep trail and back. It would be possible to have a car "pickup" at Lameshur or a boat pickup in Reef Bay to avoid long uphill walk back to centerline.

Shoreline: Tiny sand beach, with shade trees, coconut palms and old steam-operated sugar mill. Picnic facilities.

Water: Reef-filled bay.

21. FISH BAY

Location: South shore.

Access: Centerline Road to aluminum pre-fab house on right side of the road. Head of L'Esperance trail is here; 2 miles down to Fish Bay, or take Monte Road (right fork at gas station) to ridge above abandoned settlement of Monte. This overlooks Rendezvous Bay; and footpath leads diagonally down into Fish Bay.

Shoreline: Mangrove at head, steep hillside on west, sandy and muddy beach on east.

Water: Shallow muddy-sandy bottomed bay, covered with turtle grass. Much of it wadable. Reefs at entrance. Always very calm.

22. RENDEZVOUS BAY

Location: Southwest shore.

Access: By trail from abandoned village of Monte. Take right hand fork at Texaco station in Cruz Bay and drive to top of ridge above Monte.

Shoreline: Mostly steep, rocky, with heavy vegetation; small sandy beach on east end.

Water: Steep dropoff from rock outcrops into reef-filled water. Slopes gently to turtle grass bottom from sandy beach. Often rough, except at sand beach where surges sometimes occur, but usually calm.

SHORELINE FISHING – ST. JOHN

23. HART BAY

Location: Southwest shore.

Access: Same as #22, except take private Chocolate Hole road at bottom of very steep hill. Turn at first left from Chocolate Hole junction and drive to end of road. Hike remaining few hundred yards to beach. Chocolate Hole Estates are private and lots extend to water. Don't trespass on building sites.

Shoreline: Sandy-cobble beach with steep rocks at each end. Some shade, but mostly open.

Water: Rough, sometimes wild, with a well-developed reef immediately adjacent to shore.

24. CHOCOLATE HOLE

Location: Southwest shore.

Access: Same as #23, except continue straight after Chocolate Hole Junction. All roads and lands are private.

Shoreline: Head of bay is sand beach owned by a hotel firm. Both sides of beach are rough and rocky and all privately owned. Some owners resent intruders.

Water: Slopes rather gently to turtle grass bottom. Usually calm, especially east side.

25. FRANK BAY

Location: In Cruz Bay Village.

Access: Take road south along Cruz Bay beach past Gallows Point Hotel and continue right down steep incline to parking area.

Shoreline: Mixed sand, beach rock and stone. Little vegetation or shade.

Water: Mixed reef and sand areas. Sometimes rough but usually fairly calm.

SHORELINE FISHING - ST. THOMAS

1. FORTUNA BAY (eastern portion)

Location: West end, south shore.

Access: West on Brewers Bay Road (past College of the Virgin Islands) to Fortuna Bay Road. At "Fortuna Estates" sign, just before housing development, turn left down steep paved road. At end of paved road, continue straight on dirt road to shore. Private property, but fishing permitted (no spearfishing).

Shoreline: Rock and pebble beach, much litter. Rocky and steep at both ends of bay.

Water: Large coral-covered boulders scattered over generally rocky bottom, which drops off rapidly. Large bed of turtle grass in center of bay. 50 to 60 feet deep off points at ends of bay. Generally fairly calm.

2. BREWERS BAY

Location: South shore, west of College.

Access: Brewers Bay Road, just west of College, dips down and runs along beach. Park on either side of road.

Shoreline: Sand and coral rubble, with some areas of beach rock.

Water: Bottom varies from pure sand to turtle grass beds to coral shelves, sloping moderately, except at western point (known locally as "Black Rock"), where bottom is very rocky and drops off sharply to 50 feet a short distance from shore. Apt to be a surge.

3. LINDBERGH BAY (east side)

Location: South shore, south of airport.

Access: After turning onto airport road from Harwood Highway, take first dirt road to left. Keep to right on this road, taking far right road at storage tanks; this road dead ends in small parking area 50 feet from shore.

Shoreline: About 50 yards of stony beach with projecting rocks at both ends. Some scrub on hillside.

Water: Bottom primarily sand, with occasional grass patches and coral-covered boulders. Slope is about 30 degrees. Depth of 30 feet near rocks. Thermal pollution of surface water from outflow near center of shore. Very calm.

4. CROWN BAY AND SUBMARINE BASE

Location: South shore, west of town.

Access: Turn-off on newly paved road at Wayne Aspinal Junior High School, or turn left at first stop light on Harwood Highway west of town.

Shoreline: Sub-base area at west end of Crown Bay is a series of docks, from which fishing is permitted; inquire to be sure. Area from Pier 2 (restaurant) to Coca-Cola plant is private. Small sand beach east of Coca-Cola plant. Long concrete bulkhead along shore, east of beach with boat ramp and rocky shore further east.

Water: Up to 35 feet at piers, where large vessels can moor, sand and grass bottom off sand beach area; moderate slope. Depth 20 to 25 feet adjacent to concrete bulkhead, where bottom is mostly sand with scattered grass patches. Rocky bottom east of boat ramp. Usually calm.

5. ST. THOMAS HARBOR (Charlotte Amalie)

Location: Waterfront in town.

Access: Center of town.

Shoreline: Public wharf, about one mile long, has wide concrete sidewalk between bulkhead and Veteran's Drive; fishing permitted any time, but apt to be crowded in day time. Point of land in center of harbor area (opposite Fort) contains U. S. Coast Guard Station and dock, where permission to fish must be obtained from guard on duty. Fishing on eastern side of point permitted anytime. Narrow sidewalk atop low, bulkheaded shore from point of land to pebble beach beside Yacht Haven.

Water: Generally turbid, polluted by many sewage outfalls and by discharges from moored vessels in harbor. Bottom sand, silt, mud and refuse. Rocky bottom off point at Coast Guard Station. Depth 20 to 30 feet at Public Wharf, more gradual slopes off bulkheaded sidewalk at east end of harbor and at Yacht Haven beach. Generally fairly calm, although can be very choppy at times.

6. MORNINGSTAR BEACH

Location: South shore, southeast of town.

Access: East of Veterans' Drive, take road to right, beyond Yacht Haven. Continue straight where road has divider; leads directly to beach. Public beach with admission charge.

Shoreline: Long sandy swimming beach. Steep and rocky at both ends of bay.

Water: Pure sand bottom off swimming area, with large grass area offshore. Coral-covered rocks off rocky shoreline at beach ends. May be rough.

7. BOLONGO BAY

Location: South shore, east of town.

Access: East of Veterans' Drive, take road to right, beyond Yacht Haven. Turn left at short road divider. Road passes close to shore.

Shoreline: Bolongo Bay Beach Club shore is private and restricted to occupants and members. Areas on both sides of beach club are sandy beaches, with steep rocky land at both ends of bay. Rocky shore east of east point.

Water: Moderately sloping sand bottom off beach areas has grass beds, coral patches and scattered boulders. Rocky bottom off rocky shoreline, with coral reef point to east. Dredging operations in bay causes water to be generally turbid. High surf during south-easterly winds.

8. LONG POINT - PATRICIA CAY ("Major's Beach")

Location: South shore, towards east end.

Access: Dirt turnoff from Bovoni Road, about 1/2 mile west of abattoir. It is advisable to inquire at one of the stores in Bovoni area, for exact directions. Dirt road not maintained and is difficult in rainy weather; steep in some areas. Steep, overgrown trails lead from road to shore on both sides of point. Road ends at beach.

Shoreline: Rocky along Long Bay side of point. Sand and pebble beach at end of road, facing Patricia Cay. Mangroves along lagoon side of point.

Water: Sharp drop-off to 20-30 feet along rocky shore to west; bottom is coral with many ledges. Deep trench right off beach area, with sand and grass bottom. Extensive coral and sand flat connects point with Cay. Bottom in lagoon is sand and silt, with some grass and occasional coral heads.

SHORE LINE FISHING - ST. THOMAS

9. **CABRITA POINT**

Location: Easternmost point of St. Thomas.

Access: Red Hook Road to fork in road after descending steep hill. Take right turn at sign indicating "Bluebeard's Beach" and "Vessup Bay Estates." Follow road and turn left at "Parker/Hetrick" sign, go to end of road and turn right. If passable, drive across sand flat to foot of hill; if not passable, park west of sand flat. Long walk over hills to shore at point. (Fishing may be done along shore en route to point.)

Shoreline: Very rocky at point with rubble and dirt debris.

Water: Rapid drop-off at point. Bottom covered with rocks and coral.

10. **NATIONAL PARK SERVICE DOCK**

Location: East end of island.

Access: Red Hook Road to fork in road after descending steep hill. Take paved road indicating National Park Service. Large parking area at dock.

Shoreline: Concrete dock. Inquire of ranger on duty, concerning permission to fish and about suitable adjacent areas.

Water: Shallow. Gently sloping bottom is sand and grass. Usually calm.

11. **SAPPHIRE BEACH CLUB (St. John Bay)**

Location: East end of island, north of Red Hook.

Access: Smith Bay Road or Red Hook Road. Admission charge, but guests are permitted to fish.

Shoreline: Rocky promontory at south end of bay **suitable for fishing.**

Water: Rocky bottom, large coral heads in 20 to 30 feet of water off promontory.

12. **COKI BEACH**

Location: North shore, east end.

Access: Smith Bay Road. Follow road indicating Pineapple Beach, going100 yards beyond this facility. Admission fee nominal.

Shoreline: Rocky points at both ends of pure sand beach. Food, beverages and diving equipment available for rent. Some trees along shore.

Water: Bottom slopes rather quickly into channel between St. Thomas and Thatch Cay. Water usually clear and usually calm.

13. TUTU BAY

Location: North shore, northeast of town.

Access: Same as Mandal Bay (#14), except turn right at bottom of hill, just before salt pond. Park at end of dirt road and walk to beach via very short path at left.

Shoreline: Sand and broken coral, with limestone shelves often exposed. Scrub behind beach. Steep rocky cliffs at both ends of beach. Private home near beach, at west end.

Water: Fairly shallow, with gentle slope to mouth of bay. Bottom largely coral-covered rocks and boulders. Generally heavy wave action.

14. MANDAL BAY

Location: North shore, northeast of town.

Access: Turn off Mandal Road at sign marked "Bali Hai Hotel." Take sharp right after "Mandal Salt Pond Marina" sign and follow this road to beach.

Shoreline: Varies with season, from all sand to sand and broken coral. Palms and other trees behind beach. Rocky cliffs at both ends of beach. Dredging and marine construction may alter shoreline.

Water: Conditions vary during year: sometimes exposed coral ledges at shoreline and sometimes all-sand bottom at center. Bottom off points at either end of bay 30 feet deep and covered with coral-covered rocks and boulders. Considerable wave action.

15. MAGENS BAY

Location: North shore, north of town.

Access: Magens Bay Road leads directly to beach, which is owned and maintained by local government. Admission and parking charges 25¢. Snack bar restaurant.

Shoreline: Spectacular sandy beach with rugged coastline on either side of large, deep bay. Palms and shade trees back entire beach.

Water: Bottom mostly sand, with some grass patches in center of bay a considerable distance from shore. Some boulders along north bay coast, but little coral. Very little water circulation and very calm.

16. HULL BAY

Location: North shore, north of town.

Access: Hull Bay Road directly to beach.

Shoreline: Sandy beach, backed by trees (including manchineel). Rocks and coral ledges at water's edge. Rocky points at both ends of beach.

Water: Small dropoff beyond shore ledge. Bottom sand, grass patches and coral. Extensive coral patches off points. Fairly calm, except at western extremity.

17. NE LTJBERG BAY

Location: Northshore, northwest of town.

Access: Crown Mountain Road to Virgin Islands Agricultural Station. Turn down new very steep concrete road marked "Dorothea Beach." Just before entering Dorothea Beach resort, take sand road to left, through palm grove to Neltjberg Bay. Do not try any other **access!**

Shoreline: Wide sand beach backed by palms and scrub trees. Gravel and steep rocky shore to east.

Water: Shallow. Sandy bottom with grass bed coming almost to beach. Extensive reefs off both ends of bay.

18. STUMPY BAY

Location: North shore, west end.

Access: Brewers Bay Road past College, continuing on Fortuna road. Just before Fortuna Road makes a sharp left turn, a very steep dirt road, to right, leads to Stumpy Bay.

Shoreline: Central sandy beach, with some boulders. Rocky shoreline on either side of bay. Rocks at far east point are best fishing area. Exercise caution; swells here have swept fishermen away.

Water: Relatively deep, with considerable coral formations. Rocks and boulders cover bottom off eastern rocky points. Apt to be rough.

NOTES ON SPECIES COMMONLY CAUGHT IN THE VIRGIN ISLANDS OFFSHORE

Blue Marlin

Size: Average 250 pounds; two most recent world records (814, 845 pounds) caught in the Virgin Islands Waters.

Habitat: Blue water; caught at edge of 100 fathom shelf.

Season: Year-round; best time: July-October.

Method: Trolling with outriggers from charter boat.

Bait: Mullet or other suitable fish weighing from 1/4 to 10 pounds.

Tackle: 80# - 130#

White Marlin

Size: Average 45 pounds.

Habitat: Blue water; at edge of 100 fathom shelf.

Season: Year-round; best time: spring and fall.

Method: Trolling with outriggers from charter boat.

Bait: Small mullet or ballyhoo.

Tackle: 30# – 50#

Sailfish

Size: Average 45 pounds.

Habitat: Blue water; caught inshore and sometimes at edge of 100 fathom shelf.

Season: Occasional fish year round; best time: January-February.

Method: Usually by trolling with outriggers from charter boat; sometimes by casting from small boat.

Bait: Ballyhoo, strips, artificial lures.

Tackle: 20# - 30#

SHORELINE FISHING

Wahoo

Size: Average 45 pounds; five current world records (to 124 pounds) caught in Virgin Islands waters.

Habitat: Blue water; caught at edge of 100 fathom shelf.

Season: Year-round; best time: September-May.

Method: Trolling from charter boat, with or without outriggers.

Bait: Ballyhoo, mullet.

Tackle: 30# - 50#

Allison Tuna

Size: To 150 pounds; average 40 pounds. Pending world record (76 pounds; 12# tackle) caught in Virgin Islands waters.

Habitat: Blue water; caught at edge of 100 fathom shelf and sometimes inshore.

Season: Year-round; best time: spring and fall.

Method: Trolling from charter boat, with or without outriggers.

Bait: Ballyhoo, mullet, yellow feather.

Tackle: 50#

Cobia

Size: Average 40 pounds, world record (52 3/4 pounds, 12# tackle) caught in Virgin Islands waters.

Habitat: Inshore.

Season: Winter-spring; best time: January-February.

Method: Trolling.

Bait: Ballyhoo.

Tackle: 30# - 50#

SHORE LINE FISHING

<u>Dolphin</u>

Size: Average 15 pounds.

Habitat: Blue water; caught at edge of 100 fathom shelf and sometimes inshore.

Season: Fall to spring; best time: spring.

Method: Trolling from charter boat.

Bait: Ballyhoo.

Tackle: 20 – 3(

<u>Kingfish</u>

Size: Average 15 pounds; world record (65 pounds; 130# tackle) caught in Virgin Islands waters.

Habitat: Inshore and at edge of 100 fathom shelf.

Season: Year-round; best time: spring.

Method: Trolling.

Bait: Ballyhoo, feather.

Tackle: 20# – 3(

<u>Blackfin tuna</u>

Size: Average 10 pounds.

Habitat: Edge of 100 fathom shelf and inshore.

Season: Year-round; best time: January-March.

Method: Trolling.

Bait: Yellow feather.

Tackle: 20#

SHORE LINE FISHING

Bonito

Size: Average 10 pounds.

Habitat: Edge of 100 fathom shelf and inshore.

Season: Year-round; best time: spring.

Method: Trolling.

Bait: Ballyhoo, yellow feather.

Tackle: 20#

Barracuda

Size: Average 10 pounds.

Habitat: Inshore and at edge of 100 fathom shell.

Season: Year-round.

Method: Trolling or spinning.

Bait: Ballyhoo, feather.

Tackle: 2011r

Tarpon

Size: 15 to 50 pounds.

Habitat: Inshore.

Season: Year-round; best time: spring.

Method: Casting, spinning, trolling.

Bait: Plug, spoon, sprat.

Tackle: 20# - 30#

SHORE LINE FISHING

Bonefish

Size: Average 5 pounds.

Habitat: Flats.

Season: Year-round; best time: spring.

Method: Spinning.

Bait: Crab, spoon, pink jig.

Tackle: 10#

Mackerel

Size: Average 3 pounds.

Habitat: Inshore.

Season: Year-round.

Method: Trolling, casting, spinning.

Bait: Strips, feathers.

Tackle: 12#

Amberjacks and other jacks

Size: Average 10 pounds (amberjack).

Habitat: Inshore.

Season: Year-round.

Method: Trolling, casting, spinning.

Bait: Ballyhoo, sprat, spoon, feather.

Tackle: 10# - 30#

SHORE LINE FISHING

Snapper (all types)

Size: Average 3 to 20 pounds; 60 pounds maximum.

Habitat: Banks.

Season: Year-round.

Method: Bottom fishing.

Bait: Sprat, cut bait.

Tackle: 30#

Grouper (all types)

Size: Average 10 to 15 pounds; 40 pounds maximum.

Habitat: Banks.

Season: Year-round.

Method: Bottom fishing, slow trolling.

Bait: Sprat, cut bait, yellow jig.

Tackle: 30#

Reef Fishes

Size: To 5 pounds.

Habitat: Reefs.

Season: Year-round.

Method: Fishing just off bottom.

Bait: Sprat, cut bait.

Tackle: 20#

CHAPTER V

FISH POISONING

FISH POISONING

"Fish poisoning" as a descriptive term may be applied to several distinct and separate diseases. They may be divided into two discrete categories with respect to their origins, or causative factors.

The first category is that which includes poisonings attributed to "spoiled" fish. The toxins which cause the adverse effects on humans in these instances are released by microbial organisms, as in the case of "botulism."

The second category is that which deals with toxins which are either produced or stored, or both, in the tissues of a normal, healthy, living fish. Of course, these same fish may spoil after death and thus be poisonous for two or more reasons. The following classification of these poisonous fishes is adapted from Halstead (1957).

I. POISONOUS FISHES (excluding bacterial food poisons)

A. Ichthyosarcotoxic Fishes. Those fishes that contain a poison within the flesh, i.e., in the broadest sense, musculature, viscera or **skin,** or slime which when ingested by humans will produce a biotoxication. The toxins are oral poisons believed to be small molecular structures and are generally not destroyed by heat or gastric juices.

Class AGNATHA: Lamprey and hagfishes - causing cyclostome poisonings.

Class CHONDRICHTHYES: Sharks, rays, skates, chimaeras - causing elasmobranch and chimaera poisonings.

Class OSTEICHTHYES: Bony fishes.

1. Ciguatoxic fishes - causing ciguatera poisoning.
2. Clupeotoxic fishes - causing clupeoid fish poisoning.
3. Gempylotoxic fishes - causing gempylid fish poisoning.
4. Scombrotoxic fishes - causing scombroid fish poisoning.
5. Hallucinogenic fishes - causing hallucinatory fish poisoning.
6. Tetrodotoxic fishes - causing puffer poisoning.

B. Ichthyootoxic fishes. Those fishes that produce a poison which is generally restricted to the gonads of the fish. The flesh is usually edible.

Class OSTEICHTHYES: Bony fishes - producing fish roe poisoning.

C. Ichthyohemotoxic fishes. Those fishes having poisonous blood. The poison is usually destroyed by heat and gastric juices.

ICHTHYOCRINOTOXIC FISHES. Those fishes having poisonous glands but no method of injecting the venom, such as boxfishes and cowfishes.

VENOMOUS or ACANTHOTOXIC FISHES. Those fishes with venom glands and spines, or other injecting mechanisms. Include sharks, rays, chimaeras and bony fishes such as scorpion fishes.

In this study we have been concerned only with those fishes which are known as ciguatoxic. Ciguatoxin is far more prevalent in the Virgin Islands and the Caribbean area than any other of the other types of poisonings. It should be borne in mind, however, that many fishes are capable of producing poisonings of two or three kinds.

It seems highly probable that at least 100 species of Caribbean fishes are capable of poisoning man with ciguatoxin. Halstead (1957) has documented the following 87 species. There are many other closely related species used as food in the Caribbean which, in view of all the evidence, should sometimes be toxic and, in fact, are implicated by clinical records. The identities, however, have not been carefully verified and for this reason we have not included them here. Halstead claims that any tropical marine fish can probably become ciguatoxic.

Family Albulidae	
Albula vulpes	Bonefish
Family Clupeidae	
Clupea sprattus	Sprat
Harengula humeralis	Sardine
Opisthonema oglinum	Thread Herring
Family Congridae	
Conger conger	Conger Eel
Family Muraenidae	
Gymnothorax funebris	Green Moray Eel
Gymnothorax moringa	Spotted Moray Eel
Family Ophichthyidae	
Ophichthus ocellatus	Pale-spotted Eel
Ophichthus ophis	Spotted Snake Eel
Family Belonidae	
Strongylura acus	Needlefish
Strongylura caribbaea	Houndfish

Family Hemiramphidae	
Hemiramphus brasiliensis	Ballyhoo
Hyporhamphus unifasciatus	Halfbeak
Family Acanthuridae	
Acanthurus chirurgus	Surge onfish
Family Carangidae	
Caranx bartholomaei	Yellowjack
Caranx crysos	Blue Runner
Caranx fasciatus	Jack
Caranx hippos	Jack Crevalle
Caranx latus	Horse-eyed Jack
Caranx lugubris	Jack
Caranx ruber	Bar Jack
Elegatis bipinnulatus	Leatherjacket
Selar crumenophthalmus	Bigeye Scad
Selene vomer	Lookdown
Seriola dumerili	Amberjack
Seriola falcata	Almaco Jack
Seriola fasciata	Lesser Amberjack
Trachinotus falcatus	Permit
Trachinotus glaucus	Palmometa
Vomer setapinnis	Moonfish
Family Chaetodontidae	
Holocanthus passer	Angelfish
Family Coryphaenidae	
Coryphaena hippurus	Dolphin
Family Gempylidae	
Ruvettus pretiosus	
Family Gerridae	
Gerres cinereus	Yellowfin Mojarra
Family Labridae	
Bodianus rufus	Spanish Hogfish
Lachnolaimas maximus	Hogfish
Family Lutjanidae	
Lutj anus apodus	Schoolmaster
Lutjanus aya	Red Snapper
Lutianus cyanopterus	Caribbean Red Snapper

Lutianus jocu	Dog Snapper
Ocyrurus chrysurus	Yellowtail Snapper
Family Mugilidae	
Mugil cephalus	Common Mullet
Family Priacanthidae	
Priacanthus cruentatus	Bigeye Snapper
Family Scaridae	
Scarus c oeruleus	Blue Parrotfish
Scarus coricensis	Striped Parrotfish
Scarus guacamaia	Rainbow Parrotfish
Scarus vetula	Queen Parrotfish
Family Scombridae	
Acanthocybium solandri	Wahoo
Euthynnus alletteratus	Little Tuna
Euthynnus pelamis	Oceanic Skipjack
Sarda sarda	Atlantic Bonita
Scombreromorus cavalla	Kingfish
Family Scorpaenidae	
Scorpaena brasiliensis	Barbfish
Scorpaena grandicornis	Lionfish
Scorpaena plumieri	Spotted Scorpionfish
Sebastes marinus	Redfish
Family Serranidae	
Cephalopholis fulvus	Coney
Epinephalus adscensions	Rock Hind
Epinephalus guttatus	Red Hind
Epinephalus morio	Red Grouper
Myctoperca bonaci	Blackfin Grouper
Myctoperca tigris	Tiger Grouper
Myctoperca venenosa	Yellowfin Grouper
Paranthias furcifer	Creolefish
Rypticus saponaceus	Soapfish
Family Sparidae	
Calamus calamus	Saucereye Porgie
Stenotomus chrysops	Scup

Family Sphyraenidae	
Sphyraena barracuda	Great Barracuda
Sphyraena guachancho	Guaguanche
Sphyraena picudilla	Sennet
Family Xiphidae	
Xiphias gladius	Swordfish
Family A luteridae	
Alutera monoceros	Unicorn Filefish
Alutera schoepfi	Orange Filefish
Alutera scripta	Scrawled Filefish
Family Balistidae	
Balistes capriscus	Triggerfish
Balistes vetula	Queen Triggerfish
Canthidermis maculatus	Rough Triggerfish
Canthidermis sobaco	Triggerfish
Family Monacanthidae	
Stephanolepis hispidus	Planehead Filefish
Stephanolepis setifer	Pygmy Filefish
Family Ostraciontidae	
Acanthostracion quadricornis	C owfish
Lactophrys trionus	Trunkfish
Rhinesomus bicaudalis	Spotted Trunkfish
Rhine somus triqueter	Smooth Trunkfish
Family Batrachoididae	
Opsanus tau	Oyster Toadfish
Family Antenneriidae	
Histrio histrio	Sargassumfish
Family Ogcocephalidae	
Ogcocephalus vespertilio	Batfish

Probably the most acceptable hypothesis explaining the origin and dispersal of ciguatoxin in fish is that presented by Randall (1958) and discussed in great detail by Halstead (1967), **Helfrick** et al. (1968), and Helfrick and Banner (1968). They postulated that the toxin, or a precursor of the toxin, is present in one of the many species of Bluegreen algae (probably Lyngbya majuscula) which colonize new, virgin, or barren areas often on, or near, reefs. Herbivorous species of fishes ingest the algae as a part of their diet and become toxic. These fishes are eaten by carnivorous fish which in turn become toxic. The toxin is cumulative with the result that the larger carnivores are more apt to be highly toxic than any of the smaller fishes. Many of the observations that have been made in the Pacific, as well as in the Caribbean, fit very well into this concept. Halstead and Randall relate cases of bombed areas and other newly opened spaces where ciguatera appeared after being previously unknown. They also cite instances where ciguatera ceased to be a problem after many years of poisoning in a given area. The new areas would have been colonized by an alga such as Lyngbya which would gradually be replaced during the process of ecological succession in the area. Thus, ciguatera could come and go with the ecological changes.

In our own studies, it was found that the livers of a great many fishes were highly toxic and produced all the symptoms of ciguatera poisoning in mice. Helfrich et al. (1968) found this true also. Thus it seems possible that the toxin could be stored in the livers of fishes and released into the tissue under certain sets of stimuli, such as sex hormone release or length of day. This would help explain the widely held belief that the disease is seasonal as wellas geographical in distribution. Helfrich and Banner (1968) discuss the possibility that the toxin could be excreted over a period of time but conclude that it may remain for the life of the fish in the case of large predators.

We were unable to establish with certainty that the liver toxin was actually ciguatoxin, but bio-assays using massive doses of vitamin A ruled out the possibility of vitamin A poisoning. We conclude that 57 positive results from a total of 61 tests is a significant figure and that the livers of many local fish are toxic.

In the Virgin Islands it is difficult to obtain exact data on the incidence of poisonings from this cause since many of the victims do not seek medical help. There is also some margin of error in clinical diagnosis where these are made.

Hogsett (1969), in the course of other work with clinical records from Knud-Hansen Memorial Hospital in Charlotte Amalie, St. Thomas, extracted data with respect to fish poison cases. The two samples are from different years and seem to indicate a decrease in the number of treated cases. Table 19 presents these data.

Rathjen (personal communication) has indicated that ciguatera poisoning poses a serious problem in snappers caught on the Anguilla Bank during current FAO exploratory fishing efforts, and Halstead (1958) records 60 outbreaks in the Caribbean since 1601. Eighteen of these were in the Virgin Islands and Puerto Rico and involved more than 118 people. There were only 2 deaths among the 118. In the Lesser Antilles he records 25 outbreaks up to 1963; these involved more than 500 people. Of more than 4,497 persons recorded by Halstead as being poisoned by ciguatera, a minimum number of 542 died. This is a world-wide mortality rate of approximately 12%. The approximations occur because of inconsistencies and approximations in the original records.

FISH POISONING

Our original objective in this study was to use bio-assay methods as they appear in the literature (Halstead, 1967) to detect poisonous individual fish. Large numbers and a great variety of fish from many locations throughout the Virgin Islands were to be tested. The resulting data would give information, not only on geographic and seasonal distribution, but also on species, sizes, and sexes of fishes involved. Accordingly, a bio-assay colony of albino mice was established with breeding animals obtained from the Chicago University Medical School. Mice had previously been used in such tests by many researchers (Halstead, 1967).

It soon became apparent that on replicate tests the mice were sometimes giving conflicting results, and that their reactions were sometimes difficult to diagnose. After considerable effort toward stabilizing procedures and results, it was concluded that our original objectives were unattainable until a more reliable bio-assay technique could be found. Accordingly, other bio-assay animals were sought. The Indian Mongoose (introduced into the West Indies) has been used successfully by other investigators (Halstead, 1967) and it was decided to use this animal as a control during the testing of other species. No satisfactory animal except the mongoose has been found to date. The mongoose is difficult to acquire, keep and handle in large-scale testing procedures, and it would be extremely advantageous to have a cheap, easily handled bio-assay organism that could be maintained in large numbers in a small space. Other vertebrates such as frogs and chickens have been used but problems of supply and maintenance would be serious ones under local conditions. Invertebrates such as crayfish are also effective but pose similar problems.

During the course of the study, 280 individual fish representing 16 families, 25 genera, and 32 species were tested on 14 different species of bio-assay animals in more than 500 separate tests. Each test required a minimum of 24 hours for completion after the fish sample was obtained. The animals tested included mouse, mongoose, cat, human, fairy shrimp, cricket, hermit crab, fiddler crab, isopod, octopus, chicken, sand flea, lobster and fish louse. The following test is typical of the methods employed with invertebrate animals.

Purpose:	The following tests were performed to determine if Uca pugnax (fiddler crab) could be used as a bioassay animal in screening fish for the presence of ciguatera toxin and to determine if the test would be more reliable than the present mouse test.
Collection and Maintenance of Crabs:	Fiddler crabs were hand collected from the mangrove swamp 24 hours before use. They were kept in glass boxes which contained clean beach sand on the bottom to a depth of 3-4 cm. The sand was thoroughly moistened with 300 cc of sea water. A supply of fresh tap water (50 cc in a petri dish) was continuously available. Crabs kept in boxes with a layer of sand 2 cm or less, or without added moisture, usually died within

8 hours of capture. The crabs selected for the assay were males and had a light colored carapace, established a territory, and dug a burrow.

Extraction of Fish: Two grams of the frozen musculature of a Nova Scotia cod and a toxic fish labeled No. 104 (Dog Snapper) were used. Each fish sample was homogenized in a teflon-lined 340 cc blender cup with 10 cc of pre-chilled (24°C) physiological saline. The resulting slurry was centrifuged for 25 minutes at approximately 2200-2340 R. C. F.

Assay: The crabs were weighed and measured across the widest part of the carapace and then placed, individually, in clear plastic vials with caps. The vial size was selected which allowed the crab to turn over and freely move its appendages, but not to turn around. The vials were placed in the freezer (-4°C) until the crabs lost their righting reflex (3-8 minutes). The crabs were anesthetized by cooling as a means of relaxing them so that the injection site under the bridge of the first pleopod (Snodgrass, 1952), which is tightly covered by the abdominal flap, can be more easily reached. The anesthetizing also immobilizes the crab so that pinching and vigorous movements during injection are eliminated. Those crabs which did not regain their righting reflex five minutes after injection were discarded as assay animals and another crab of equal size was injected as a replacement. (Only two of the injected crabs had to be replaced because they failed to regain their righting reflex within five minutes). Usually only two or three minutes are required for recovery. The survival time was calculated to be from the injection time to time of death. Death was defined as when the crab was no longer moving; its legs and eye stalks became flaccid and its carapace became a characteristic dark color.

Dosage: For the dose-response curve, the dosages used were .2 cc, .1 cc, .05 cc, .025 cc, .01 cc/crab. The crab's total weight does not reflect a true physiological weight because of the high variability in the ratio of chelae weight to total body weight. To ensure having comparable groups, the crabs were distrubuted into five dose-groups of nine crabs each so that the five groups had a total weight and carapace width which were matched. The largest, smallest and median sized crab of each dosage group was injected with the Nova Scotia cod extract, and the remaining six were injected with No. 104 extract.

Results: Preliminary Test:

This test was done in order to determine if the saline extract of ciguatera toxin had activity in Uca pugnax. See Table 20.

Dose-Response Curve:

This test was carried out to determine the LD_50 of ciguatera toxin in Uca pugnax. The dosage and injection regimen followed was that suggested by Diechman and LeBlanc (1943). See Table 21.

Concluding Comments: As Uca pugnax eats micro-organisms and not macro-size debris (Williams, 1965), the assay could not be based on the oral uptake of the toxin.

At this time it would appear that a bioassay colony for ciguatera using Uca pugnax (Smith) would be no more reliable than the present mouse test because of the large fluctuation observed in toxicity of the same fish on two successive days.

Various methods of extraction, homogenization and emulsification were adopted after **Halstead** (1967) and our standard procedure was the production of an aqueous extract using TWEEN as an emulsifier. The tissue was ground and centrifuged with the resulting liquid injected intraperitoneally into mice. Mongooses were simply fed a sample of flesh from the whole fish in a ratio equal to one tenth of the mongoose& body weight. See Table 22 for a resume of the tests that form a comparison of the mouse and mongoose as bioassay animals.

Of the 280 individual fish tested, 58 were judged to be toxic. Ten of the 16 families, 10 of the 25 genera, and 19 of the 32 species, were toxic. On this basis, one of five fish would appear to be toxic, but these figures are misleading: Our samples were not random; there was a deliberate effort to acquire toxic material to work with and this was accomplished by seeking very large specimens of species which are widely believed to have a high percentage of poisonous individuals in the Virgin Islands. Some of these species are: Barracuda, Horse-eye Jack, Yellowfin Grouper, Amberjack and Dog Snapper. Our data are insufficient to make a generalization about the species or sizes involved throughout the islands.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

As a result of the observations made during this project we conclude that there are many problems associated with an effort to upgrade and enlarge a commercial fishery which would be limited to Virgin Islands waters. A review of the literature and personal observation indicate that this is probably true for most islands in the entire Lesser Antilles region. No detailed discussion will be attempted regarding the possibility of developing a fleet of commercial boats that could fish anywhere in the Caribbean or Tropical Atlantic and land their catches in the Virgin Islands for processing and marketing or distribution. For a detailed discussion related to this possibility *see* Gilbert (1968); while this publication is not limited to this area it sets forth pertinent arguments and presents cogent and up-to-date data on a large-scale commercial fishery endeavor anywhere under the U. S. flag.

From the standpoint of available fish and fishing waters, the sport fishing charter boat fleet can probably expand several times. From an economic point of view, this will have to be done carefully. Table 18 reflects the fact that, in the past, expansion of the fleet occurred more rapidly than a corresponding increase in the number of anglers. As a result, several incoming boats have found it uneconomical to continue as charter-fishing boats and have either left the islands or converted to sight-seeing and general tour boats. Two commercial snapper fishing boats were also forced into the tour boat business during the course of this study. It is still too early to predict the survival rate of the most recent influx of fishing boats to the islands. Hopefully, it will be high. It is still the usual experience to fish all day without [illegible] another fishing boat.

We shall discuss, one by one, some of the difficulties of fishing in the Virgin Islands and wherever possible present our opinions on resolving them.

A. The first major difficulty, as it is everywhere in the United States (Schaefers, 1968), (Mekos, 1968), (Miller, 1968), (McKernan, 1968), is in convincing young men that there is a future in fishing and that it is possible to make an adequate and respectable livelihood from commercial fishing. As the economic survey in Chapter IV has shown, the average age of native Virgin Islands fishermen is high. This is a clear indication that young men are not fishing. It is much easier and far more lucrative to do almost anything else. In addition, even the most primitive kind of market fishing requires some capital outlay for boats and gear. This may amount to less than $1, 000 but is a deterrent nonetheless. There are, perhaps, many ways in which to attack the preceding problem. Some of the more obvious are listed below.

1. A government (or privately) sponsored and funded education program, designed for fishermen. This is currently being done in many places in the world, including other Caribbean areas and the continental United States. *See* Whiteleather (1968), Brown (1968), Navratil et al. (1968), Mc Hugh (1968), Pedersen (1968), Salo (1968), Paulik (1968), Liston (1968).

Such a program should include not only **training** in the types of boats and gear, and the methods of handling and caring for them, but also such subjects as caring for and marketing fish, general merchandizing, tax procedures, characteristics of cooperatives and their formation, methods of financing, fisheries biology and conservation, seamanship, and other pertinent disciplines.

The program should be open to any age group of either sex and made especially attractive to people who indicate a willingness to remain in the islands.

2. Financial help in the form of loans (especially small ones) or actual subsidization for procuring equipment for meeting certain criteria relative to commercial fishing.

According to our survey, some fishermen feel this would help. They could buy a new small boat or motor, build new or more traps, buy an electric reel or pot hauler, or invest in a freezer or cold storage box. Some voiced the opinion that they were as deserving of outright subsidization as are farmers. Most felt that the existing money sources are aimed at the **"big-time"** fisherman who wants a modern trawler, dragger or tuna boat, rather than the small fisherman, who is the only one actually marketing in the islands (Foster, 1968).

3. Formation of a cooperative for fishermen.

Most of the native fishermen were not much interested in this, but it is our feeling that such a venture would make available many of the features outlined in paragraphs 1 and 2 above. It would, at the same time, preserve the independence of the fishermen and thus appeal to younger men.

4. Provide a "fish-market" on each of the three major islands.

This should have landing, processing, and marketing facilities for both fresh and frozen fish. It should be **government** supervised and rigidly controlled from public health standpoints (Crowther, 1968), (Schultz, 1968). Depending upon the amount of subsidization deemed necessary, these facilities could be made available at no cost on a first-come, first-served basis, or a fee could be set which would help defray the cost of construction and operation.

It is our opinion that many fishermen would use the facilities, that it would increase fish sales and production, and that it would provide a vastly superior retail product as compared to current marketing procedures. In addition, it would be an incentive to fishermen.

B. The second major problem is the relatively high cost of procuring, maintaining and operating power boats in the Virgin Islands.

1. In addition to the stateside **F.O.B.** cost of a boat, the additional cost of stateside transportation to a shipping point, overseas transportation, and an excise tax (or import duty on foreign boat products) imposed by the Government of the U. S. Virgin Islands, adds as much as $1,000 to the cost of a 20 foot boat. It costs several thousand dollars to run larger power boats from the east coast of the continental United States to the Virgin Islands. Much of this could be subsidized for fishingboats.

2. Marine items on the shelves of marine supply houses in the Virgin Islands usually cost three or four times as much as the retail shelf price in the states.

3. There are no well-equipped boat houses or marine engine supply houses in the islands. Most critical parts must be ordered from the states as needed. This increases the parts cost because of higher non-bulk buying and shipping rates, as well as in lay-up time for the boat.

4. Mechanical and technical help in the islands is extremely limited. This results in high hourly charges, increased lay-up time, increased cost because of inefficient workmen, and overall increased cost because of generally inferior work by the majority of craftsmen.

5. Long distances and frequent rough seas result in either fewer fishing days or additional wear and tear on the boat and gear as well as increased fuel cost for the small boat operator.

Here again, a fishermen's co-op could provide many supplies, parts and services at greatly reduced prices.

C. The third major problem is one related to the lack of modern, sanitary, suitable marketing procedures and lack of education regarding the edibility and desirability of certain species which could enter the market.

1. Marketing has been discussed in paragraph A (3) and (4) above. Several species which are taken in fairly large quantities (Table 10) find little local acceptance as food fish. These include the bill-fishes, tunas, sharks, and sardine types. Advertising and education should change this since these species are readily, and eagerly, utilized in other parts of the world.

2. The problem of "fish poisoning" as a deterrent to marketing is discussed elsewhere, but the very species listed above, which are not widely accepted as food in the islands, are the ones which are the least likely to be poisonous. This is a good sales point in the promotion of these species for food.

CONCLUSIONS AND RECOMMENDATIONS

Thus far, we have discussed problems that are of such a nature that recommendations can be made toward solving them. We now approach another group of problems which are more complex. They are inherent in the physical structure of the islands, in the biology and ecology of the resource, and in other features which are not readily diagnosed or modified.

D. The first of these problems is one which at the present time makes all others academic. Ciguatera is discussed in Chapter V but its presence and effects on the retail and wholesale market value of local inshore fish are difficult to analyze. Many people have been poisoned and most people are afraid of being poisoned. It seems almost certain that if this problem can be resolved the sale of local fresh fish will increase dramatically.

1. Efforts to increase the fishing in the Virgin Islands and other Lesser Antillean islands have resulted in increased fish poisoning cases (Rathjen, 1969). Our own efforts at resolving the problem by means of testing individual fish are reviewed in Chapter V, while in C (2) above, another partial solution is suggested. In a subsequent paragraph we will discuss the possibility of increasing a presently little-developed local fishery which may, in part, help solve the problem.

2. At the present time, ciguatera in our view is a major deterrent to the future development of a local inshore fishery since many persons (and most institutions) are afraid to risk being poisoned or poisoning their clients.

E. The nature of the Virgin Islands shelf area poses severe restrictions on the numbers and kinds of fish which are present, and on the methods which can be used to harvest them.

1. Compared to the continental masses forming the northern, western and southern boundaries of the Caribbean Sea, the shelf area of the islands is miniscule. Between the edge of the shelf and the shoreline of the islands lies the total area available for fishing. We have (Chapter 1) calculated this to be approximately 2, 000 square miles in extent. This is approximately half as large as the Hawaiian shelf, where the fisheries produced 13,000,000 pounds in 1966. Most of this was tuna from offshore (Crutchfield, 1968). There are many single bays and gulfs along continental coast lines which exceed this figure several times. The Gulf of Mexico has 112,000 nautical square miles of water less than 100 fathoms deep. The state of California has 23,100 square miles of shelf.

2. Along with the small area go such things as a lack of intertidal and estuarine areas. The result of this on fish populations has been discussed in Chapter 1, but, in brief, it reduces habitat diversity and the potential for large populations of many valuable species of molluscs, shrimp and fin fish.

3. The geographic location and ecological characteristics are responsible for another phenomenon which sometimes makes fishing difficult. There is a bewildering array of species (Chapter III), each of which is present in comparatively small numbers.

   The vast single-species schools and/or large numbers of schools which are present along continental coasts or off-shore (Pease and Drennan, 1968), (Bulls and Carpenter, 1968), do not often occur on the island shelf. The schools are usually relatively small and fast-moving. Rathjen (1968) reports:

   > Over 2000 hours of scouting for fish schools throughout the Caribbean has provided information on the relative abundance of fish schools in different seasons. When evaluated by 5° squares, the frequency of sightings ranges from no schools observed to one school every three hours.
   >
   > A maximum of 1400 pounds of skipjack tuna was taken from one school.

4. These small, fast-moving schools are, furthermore, swimming over shallow, coral-studded bottom (Chapter 1) which often tears up nets, dredges or other gear (Rathjen et al., 1968), (Carpenter and Nelson,1968).

   In addition, when the schools are composed of tunas or mackerel, our experience and that of others (Rathjen, 1968), (Bulls and Carpenter, 1968), indicates that they are often (even usually) difficult to hook in large numbers, or else they are moving so rapidly that they are difficult to catch in a net. When the schools are composed of "sardine types" it takes two fast boats and crews to set a net around them. In either case, the small quantities involved, coupled with the absence of a suitable market, make such fishing unprofitable.

5. In view of the above, the expense of seine boats and seines (Petrich, 1968), (McNeely, 1968), can scarcely be justified for use over the shelf at the present time. Overcoming the mechanical difficulties and then finding a market for the fish that he might catch are insurmountable problems for a fisherman who would also have to invest many thousands of dollars for this kind of fishing.

6. The same difficulties of expense and marketing face the would-be fisherman who would like to base himself in the Virgin Islands and fish offshore for pelagic tunas and billfishes (Gilbert, 1968). Moreover, the future of the Caribbean-Tropical Atlantic tuna and billfish stock seems uncertain (Wise, 1968), (Wise and Jones, 1968), (Griffiths and Simpson, 1968), (Anon. FAO Fisheries Report No. 61, 1968), (Rathjen, 1968), (Hayasi and Honma, 1968),

(Maghan, 1968). Rathjen (1968) found FAO fishing results using longline methods discouraging and came to the conclusion that such a fishery was not suitable for "regional" (West Indian) development. FAO efforts in this area were discontinued in 1967.

F. Up to now we have discussed only the negative aspects of increasing the fishing effort in the islands. There are several positive possibilities that are worth exploring.

1. The most promising of these would seem to be a deep-water snapper fishing effort (Carpenter and Nelson, 1968). A number of exploratory trips by Project personnel, as well as two short-term efforts by Florida-trained commercial snapper fishermen, have demonstrated the existence of Black, Blackfin, Queen, Red and Silk Snapper at the edge of the shelf. If these stocks prove to be large enough to support a continuing fishery, they have two other immediate advantages. First, they are readily accepted on the local market. Second, they offer a good possibility of being free of ciguatera if they are caught from deep-water (100 fathoms or more) below the photic zone. Some snappers caught by this project at the edge of the shelf near St. Thomas, and also on the Anguilla Bank by FAO boats (Rathjen, 1969), have proven to be poisonous; it is our opinion that these fish came from water shallower than 100 fathoms. The exploratory work would have to be carefully done in developing this fishery. In addition, simultaneous testing for toxic fish would have to be carried on. Substantial catches of these species have been demonstrated by the cruises of UNDP/FAO Caribbean Fishery Development Project in the Leeward Islands (Cruise Report Number 20), and Rathjen (1968) reports average daily catches of more than 2200 pounds for this area.

2. An effort to increase the efficiency of the fish traps currently being used would probably be fruitful. During the course of some of our efforts it was ascertained by direct observation that some fish enter and leave the traps seemingly at will. Therefore, improved design, baits and methods of setting and hauling seem in order.

3. The use of miniature long-lines, both at the surface and at various distances below the surface, should be attempted from small boats. The investment is minimal, and results from two such surface lines by Project personnel were encouraging.

4. It has been shown by Bullis and Roithmayr (1968), that lights and pumps have been used successfully to harvest small schooling fishes at night. At the same time, large predator fish were sometimes caught on hook and line at the periphery of the school. If a market were available, such a method is relatively simple and inexpensive to operate on a fairly small scale. The fish might be used in a live bait fishery.

5. Myerberg (1968), has shown that sharks can be attracted by sonic pulses and Springer (1968) discusses them as a Caribbean resource. There is a steady stateside market for shark products if a shipping schedule could be worked out. It is also possible that a limited local market for flesh and teeth could be developed. Rathjen (1968), states that the UNDP/FAO Caribbean Fisheries Development Project will undertake an experimental shark fishery in 1969. This will be coordinated with processing and marketing. The project has previously (1969) shown a local acceptance for the product in Trinidad. (*See* Table 11 for Virgin Islands species).

6. Cephalopods (squids and octopus) according to Voss (1968), (1969), and our own observations, are numerous and could very probably support a substantial fishery. They are rarely fished for in the Virgin Islands and the size of the potential market for "sea cats" is unknown. Frozen and packaged squid are already sold in the local supermarkets so that a market of sorts exists. In addition to their use as a table item, a potential use would be for bait in other fisheries. Voss discusses hooking and spearing, baits and lures, traps and pots, trawls and seines, cast nets, jigging and night lighting as methods of harvest. The capital outlay for all these (except trawls and seines) is small and certainly within the reach of individual fishermen as is shown by the existence of the fisheries in other parts of the Caribbean.

7. Consideration should be given here to a subject which has recently received considerable publicity in the non-scientific community. Aquaculture, or mariculture as it should be called when it refers to "farming of the sea," probably has great future potential. However, it should be realized at the outset that we have been unable to discover a single economically reliable aquaculture technique in operation as an industry in the United States. This includes the sometimes-profitable, fresh water catfish farming which has been in existence longer than any other such venture. There are many reasons for this and some of them will be mentioned. See also the papers by Idyll et al. (1968), Broom (1968), Provenzano (1968), Ingle and Witham (1968), Inversen and Berry (1968), Webber and Riordan (1968), Menzel (1968).

   The most serious problems that are encountered in farming aquatic organisms are biological ones. These can be minimized in some cases if it is realized that there are basically two types of "farming."

   One of these is better described as a feed-lot operation, and it is somewhat analogous to the fattening of beef calves, hogs or chickens, over a relatively short period. However, even here there is only a superficial similarity. In the case of terrestrial farm animals one is dealing with organisms which have been domesticated for very long periods of time and whose biology is almost as well known as that of human beings. Even the individuals which come to the feed lot have been produced under domestic farming conditions. This state of affairs is approached in aquatic organisms in only a few species such as channel catfish, trouts, carp and goldfish. In the vast majority of other cases, eggs, juveniles or adults are harvested from wild-bred populations and enclosed or restrained for further growth or development.

The second type of operation is one of "true" farming which has already been briefly mentioned above. In this case, succeeding generations are bred and reared entirely under controlled conditions. There are very few aquatic organisms which have been brought to this stage of development at the present time, even on an experimental basis. In the case of some of the fin fishes mentioned above there are a few large producers of eggs, larvae, or fingerlings, who distributed their "product" to a large number of "feed-lot farmers." The feed-lot operator is entirely dependent upon his source of material. It frequently happens that, for biological reasons, the large producer fails to produce.

Complicated life histories, unknown food requirements, unavailability of suitable food, diseases and parasites, and rigid water-quality requirements are a few of the biological problems which still must be solved for nearly all aquatic animals.

To overcome all these difficulties costs money, and even the terrestrial farmer finds such costs a critical item. In today's competitive world, cost accounting techniques have forced nearly all small farmers out of business. In sea farming, the farmer has to compete with the commercial fisherman, as well as his competitor farmers. High standards of living and high wages in the United States make this a difficult proposition.

In spite of these obviously very serious difficulties, we feel that research should be carried on in this field and that pilot projects should be established wherever sufficient knowledge is available to do so. Tropical climates and tropical waters offer some very distinct advantages for this kind of project and the Virgin Islands should certainly play a role in the development of the sea in coming years.

Some local species which seem to offer some promise for farming experiments are:

a. Turtles (all five marine genera), (Secty. ICUM, 1969).

b. Conch (Strombus gigas), (Project conclusion, Voss, 1968 a).

c. Whelks (Cittarium (Livona) pica), (Project conclusion, Voss, 1968 a).

d. Mangrove Oyster, (Crassostrea rhizophorae), (Riordan, 1968).

e. Spiny lobster (Panulirus argus), (Ingle and Witham, 1968).

f. Octopus (at least three species), (Voss, 1968 c).

g. Squid (at least four species), (Voss, 1968 **c).**

h. Crabs (several marine and terrestrial species), (Project conclusion, Voss, 1968 a).

In addition to these organisms and industrial potentials, there is the possibility of establishing an FPC (Fish Protein Concentrate) plant in the islands (Parman, 1968). This would depend upon the existence of a suitable fishery, but it might also develop simultaneously with a fishery which would utilize bait fish, small tunas or sharks.

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APPENDIX A

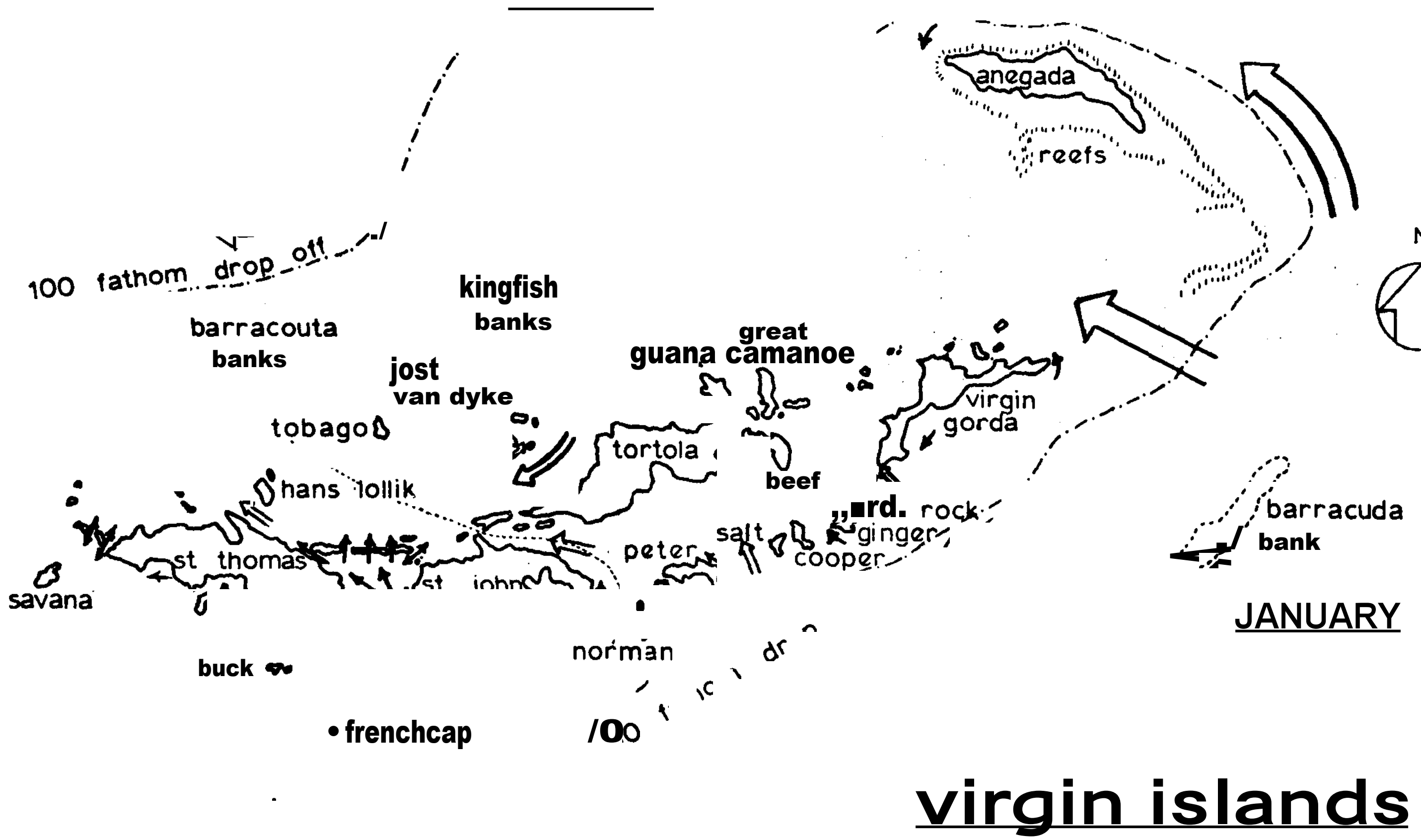
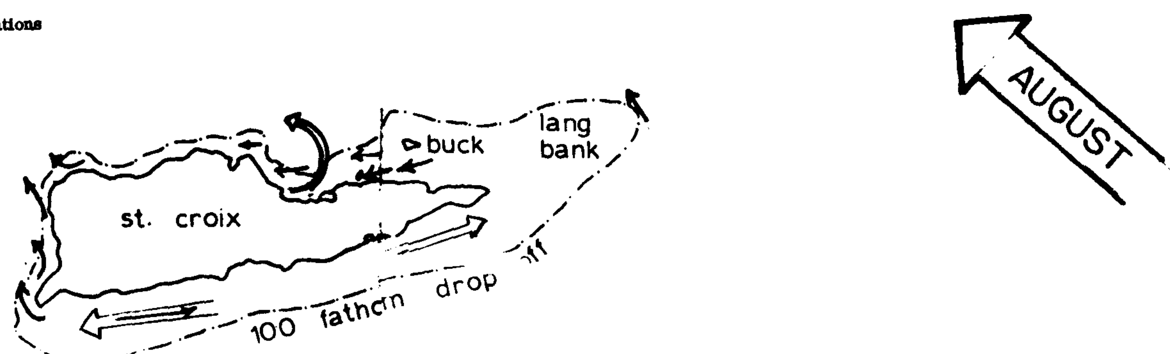


CHART NUMBER 1

Some general current observations in the Virgin Islands



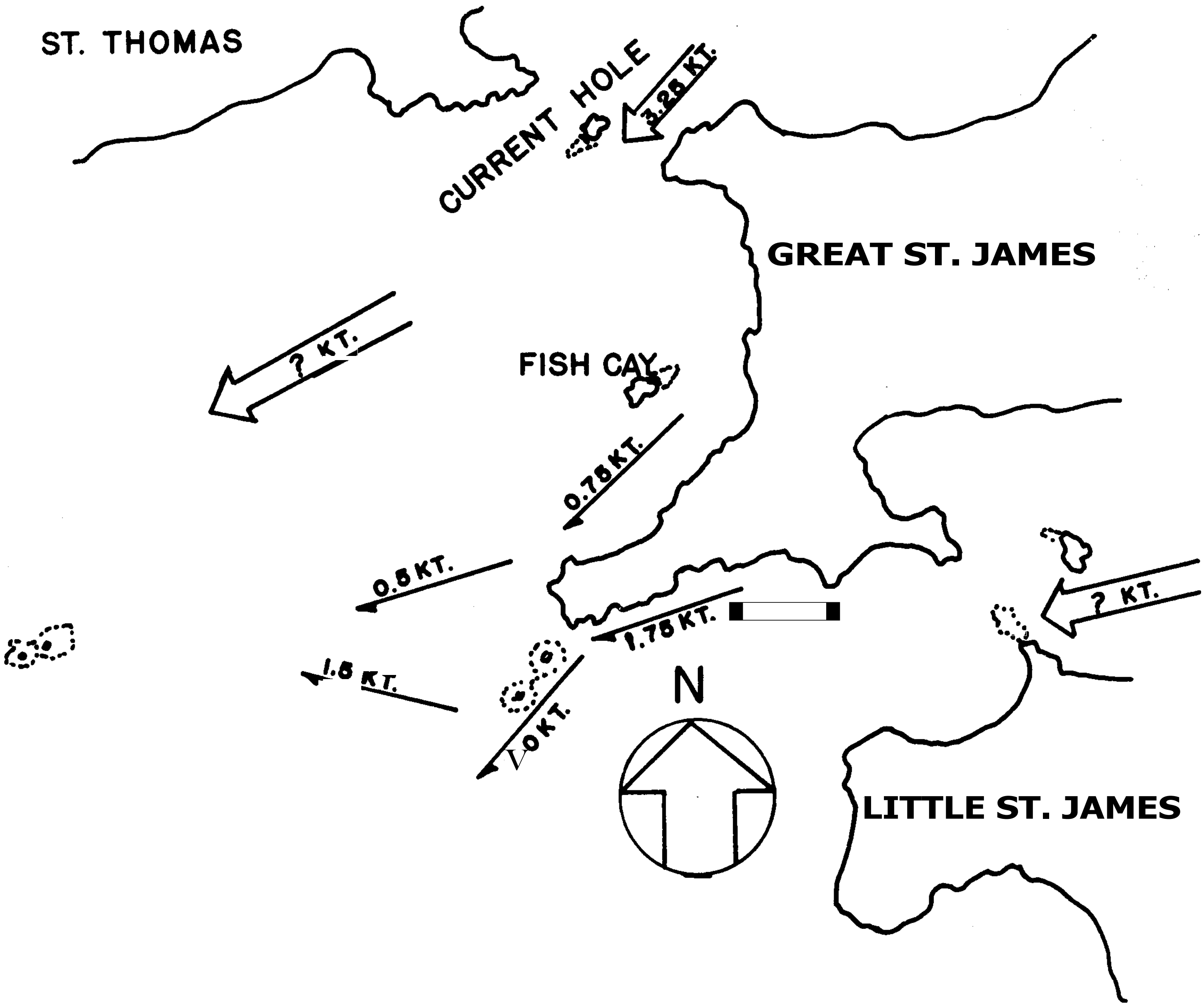


CHART NUMBER 2

Local August currents as calculated with the use of a dye marker. Wind steady ESE 8-12 knots with infrequent gusts to 15-18 knots. Air temperature 28.0 C. Scale 1 1/4" = 500 yds. (after Brody, unpublished)

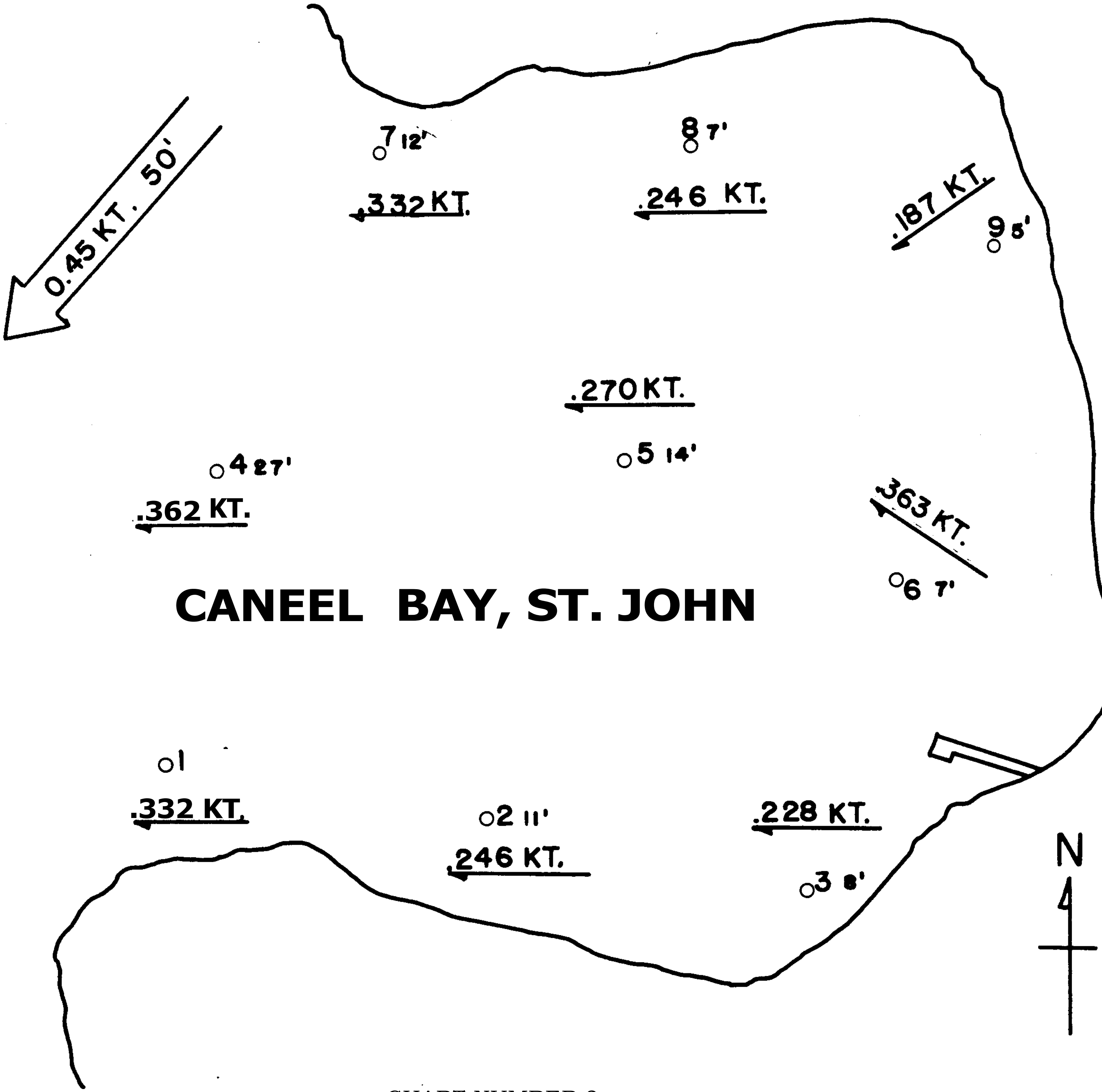
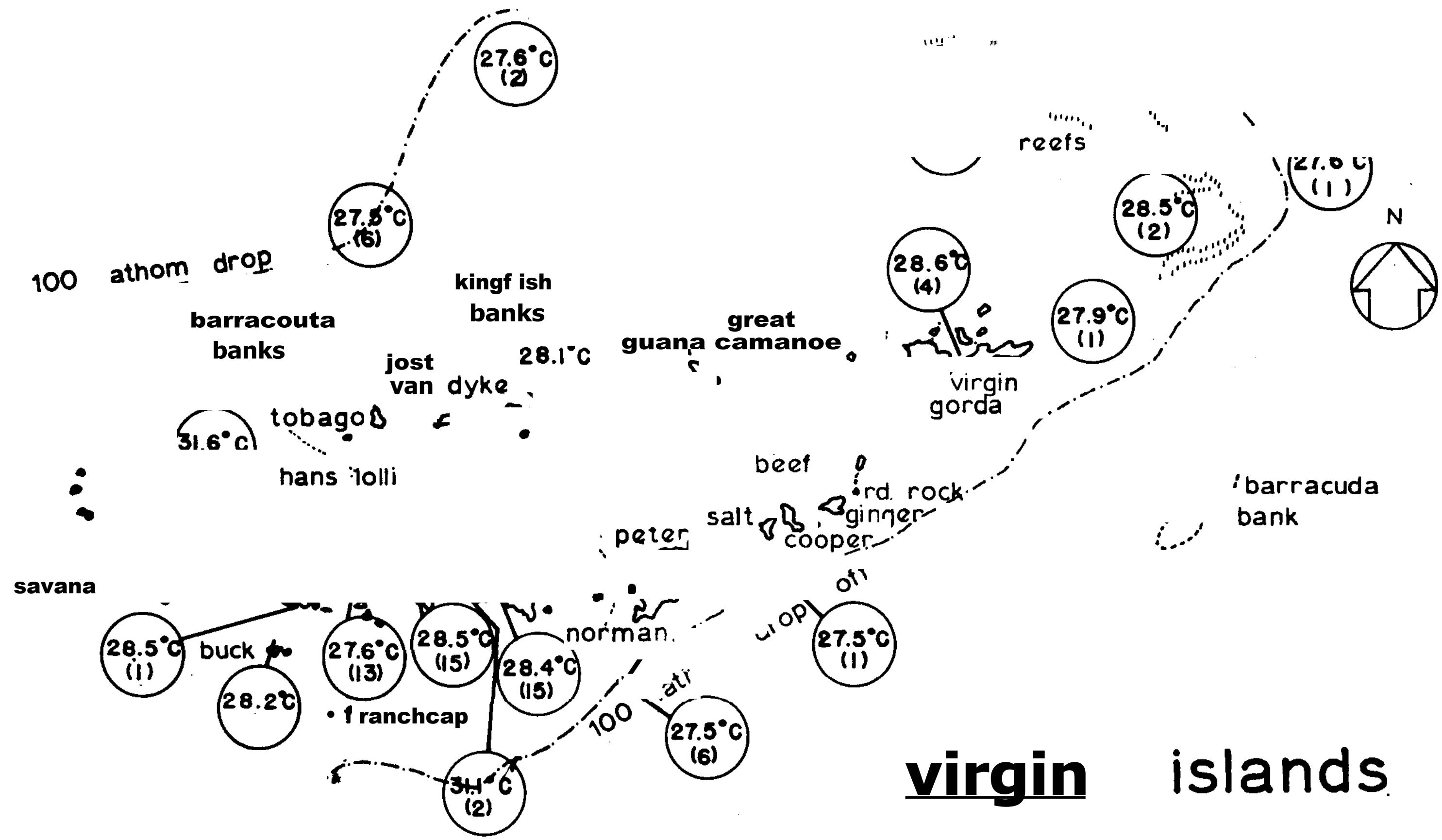


CHART NUMBER 3

Maximum bottom currents recorded by a Niskin meter in a study of a typical shallow bay.

Depths are in feet.
Currents are in knots.
Salinity range, 35. 2-35. 5 ppt.
Temperature range, 29.3-30.2° C
Wind maximum, 10-15 MPH
Scale 1'' = 150'



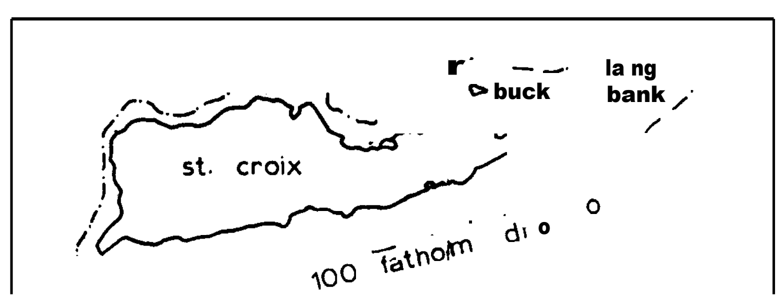
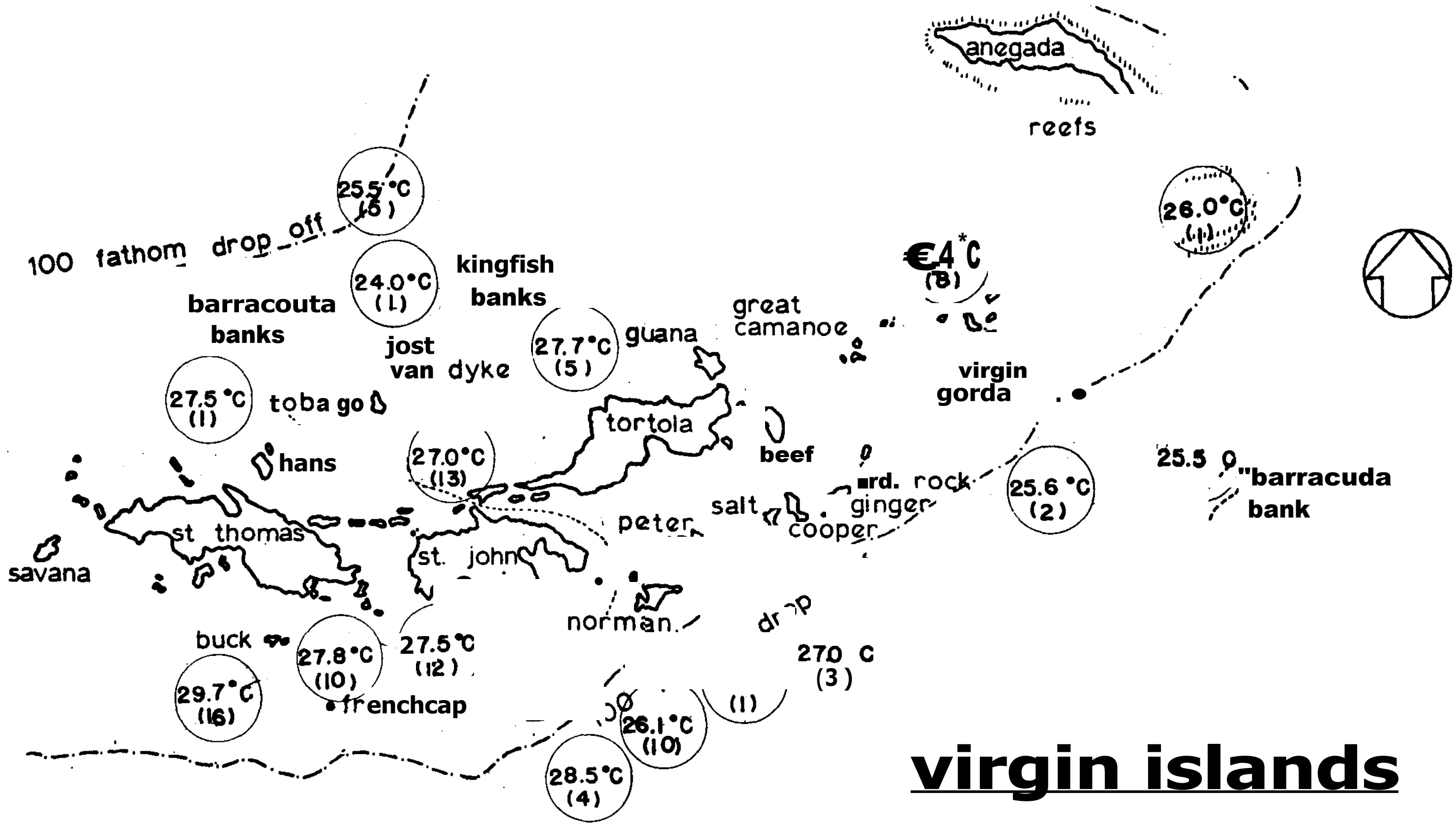


CHART NUMBER 4

August S T

Temperatures **separate-day** .



virgin islands

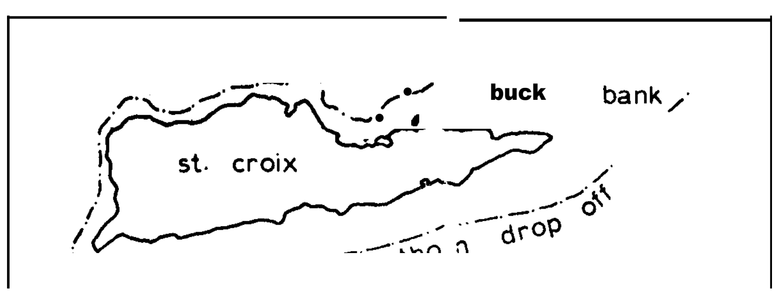


CHART **NUMBER** 5

A **Surface** T

T -.

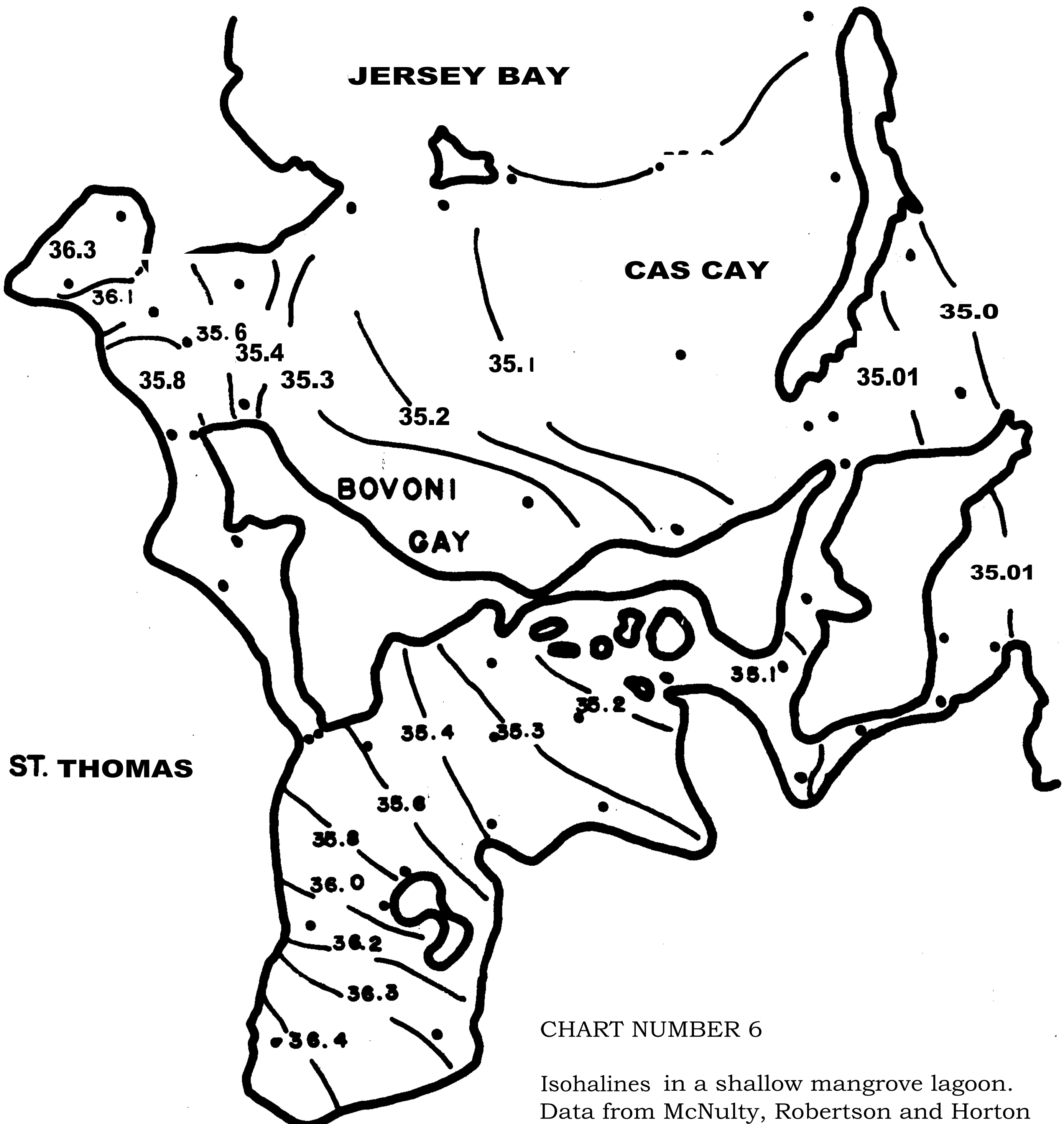


CHART NUMBER 6

Isohalines in a shallow mangrove lagoon. Data from McNulty, Robertson and Horton (1968), combined with Project data to produce a 12 month average.

•indicates station

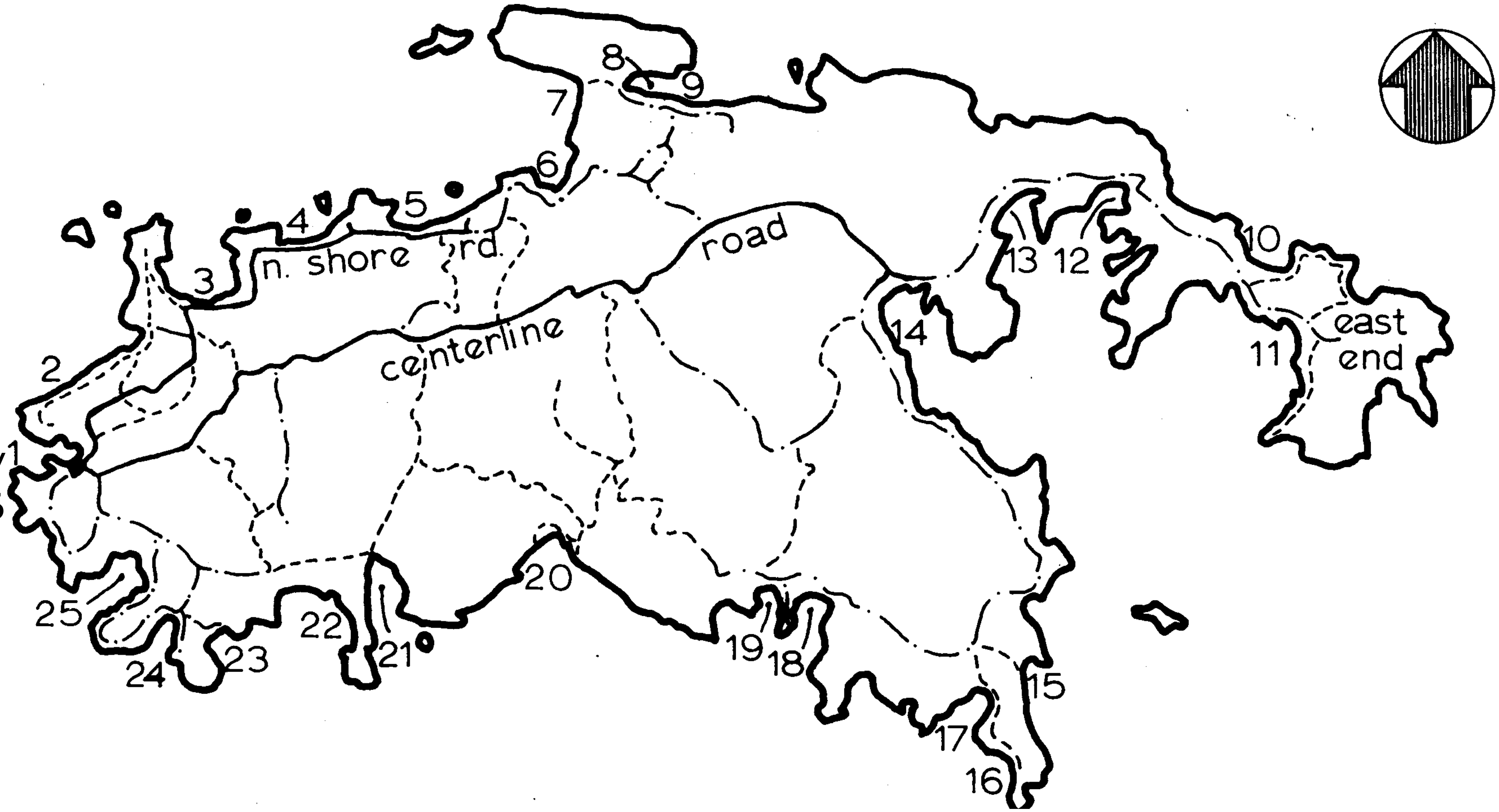


CHART NUMBER 7

john shoreline fishing

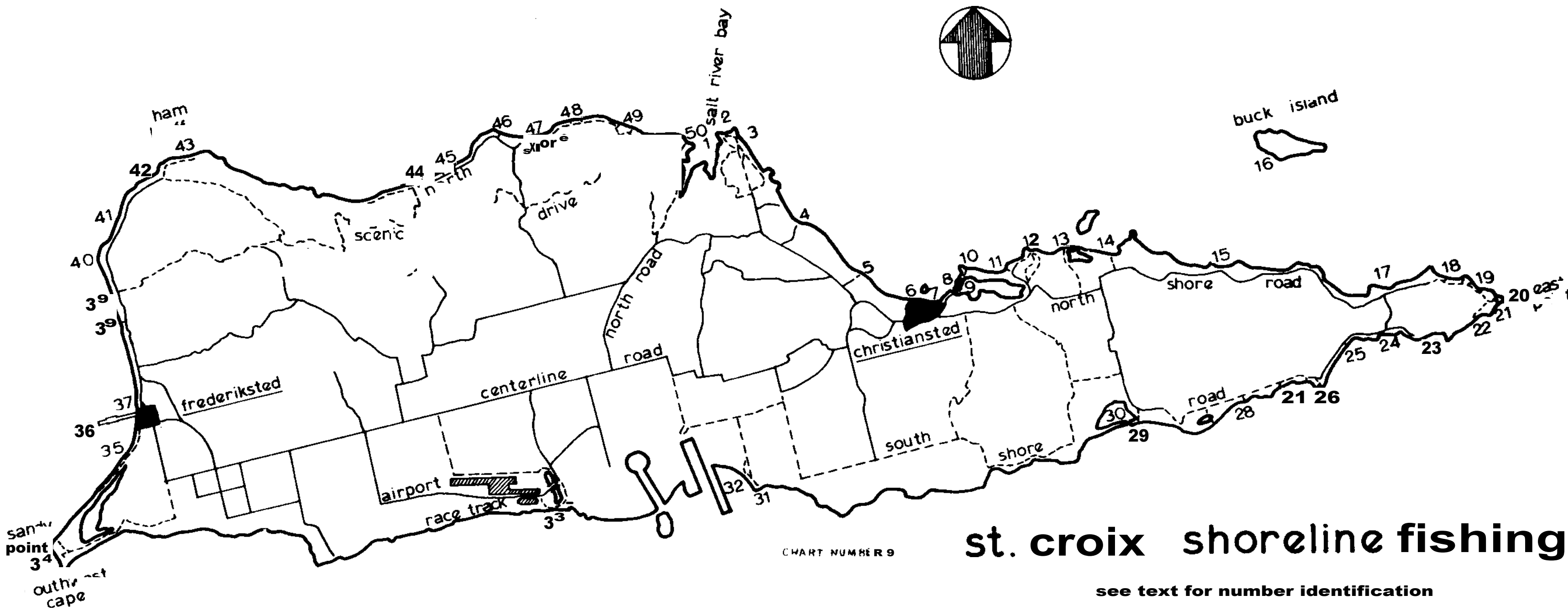
see text for number identification

paved roads

unpaved roads

---- trails

1969



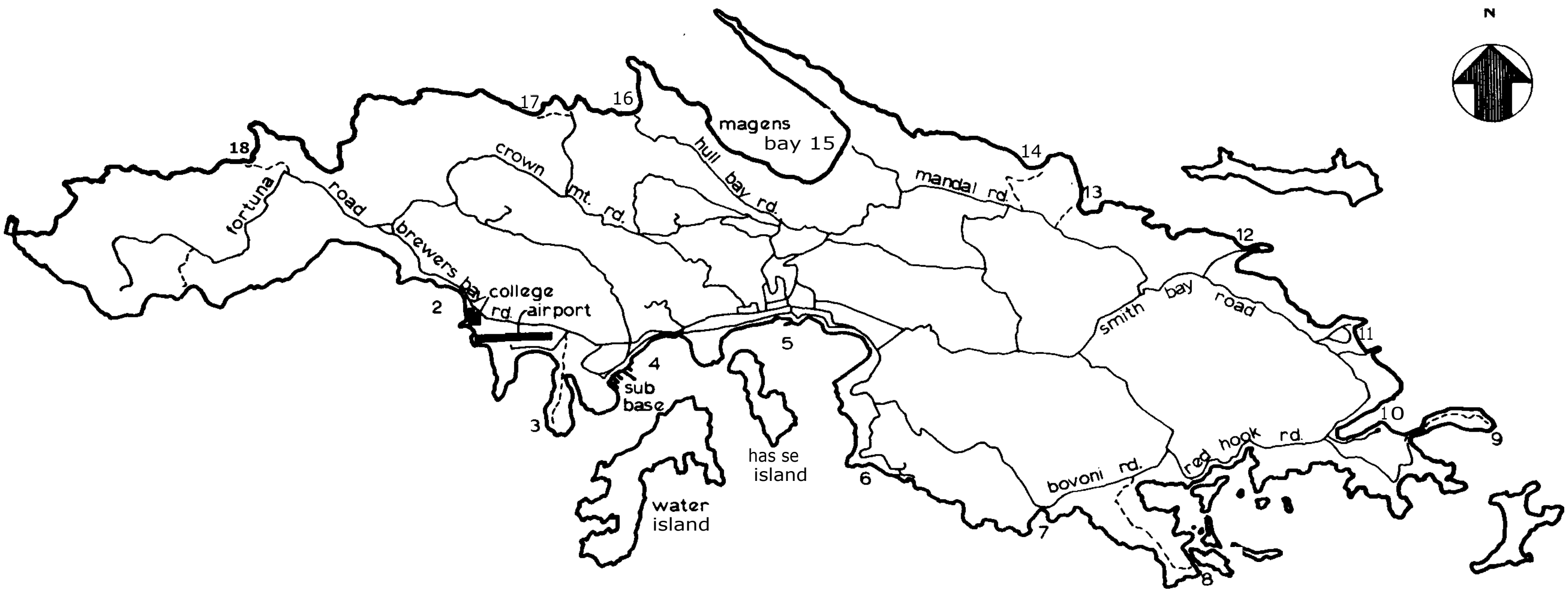
st. croix shoreline fishing

see text for number identification

—— paved **roads**

- - - **unpaved roads (partial)**

1969



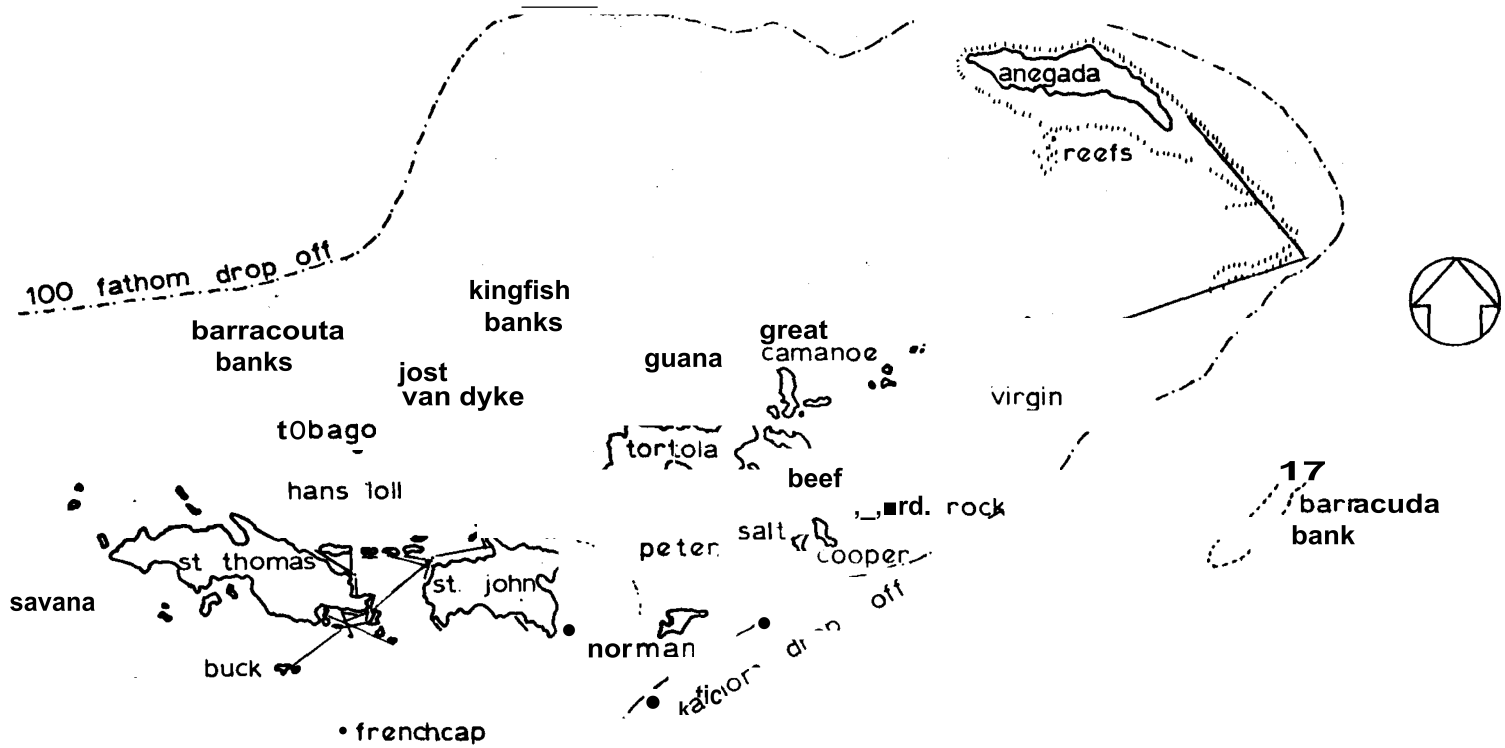
st. thomas shoreline fishing

see text for number identification

— paved roads

--- unpaved roads (partial)

1969



virgin islands

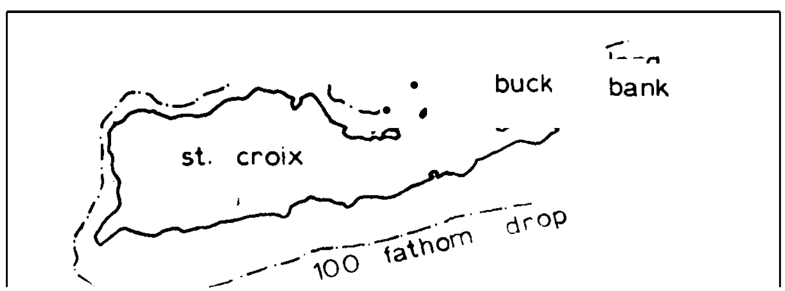


CHART NUMBER 10

Transects of bottom types as run with glass-bottomed barge

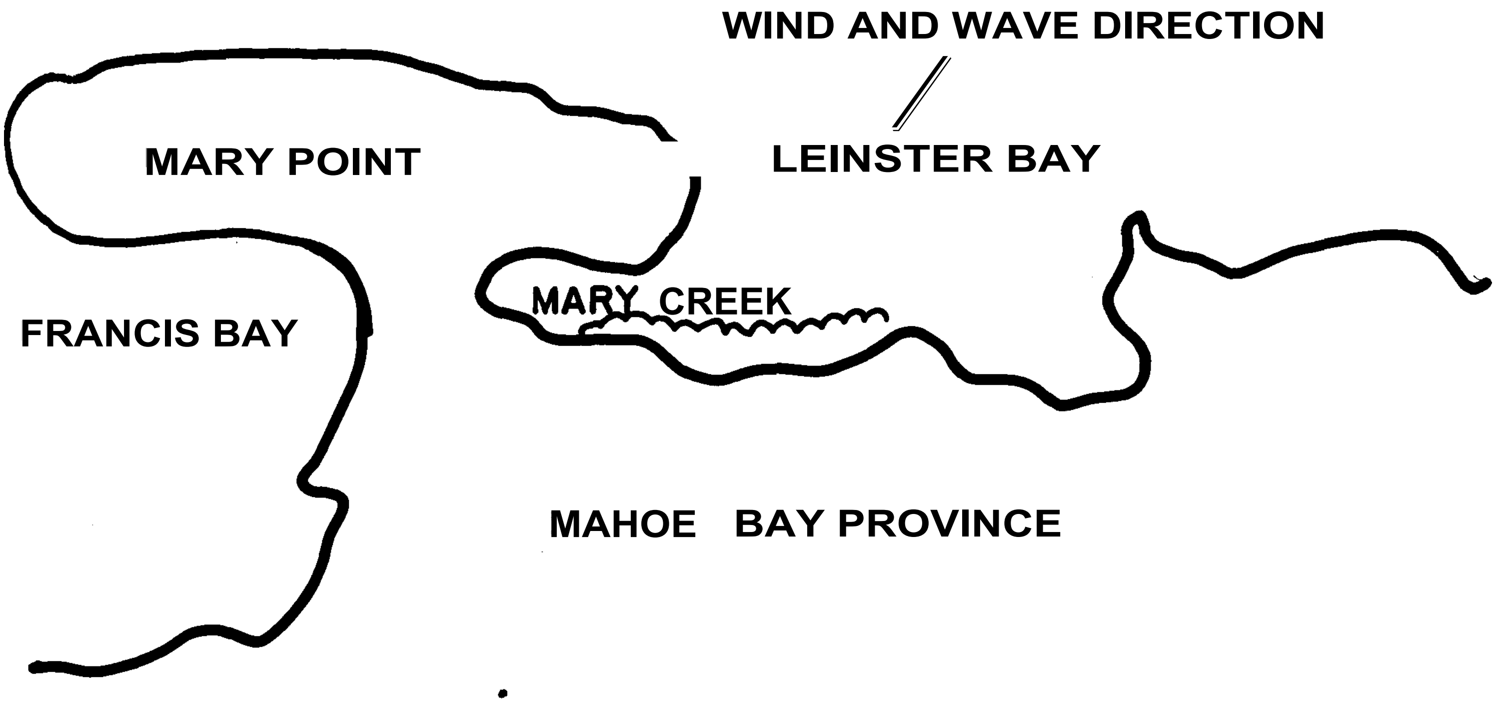


FIGURE I. MARY CREEK REEF AREA

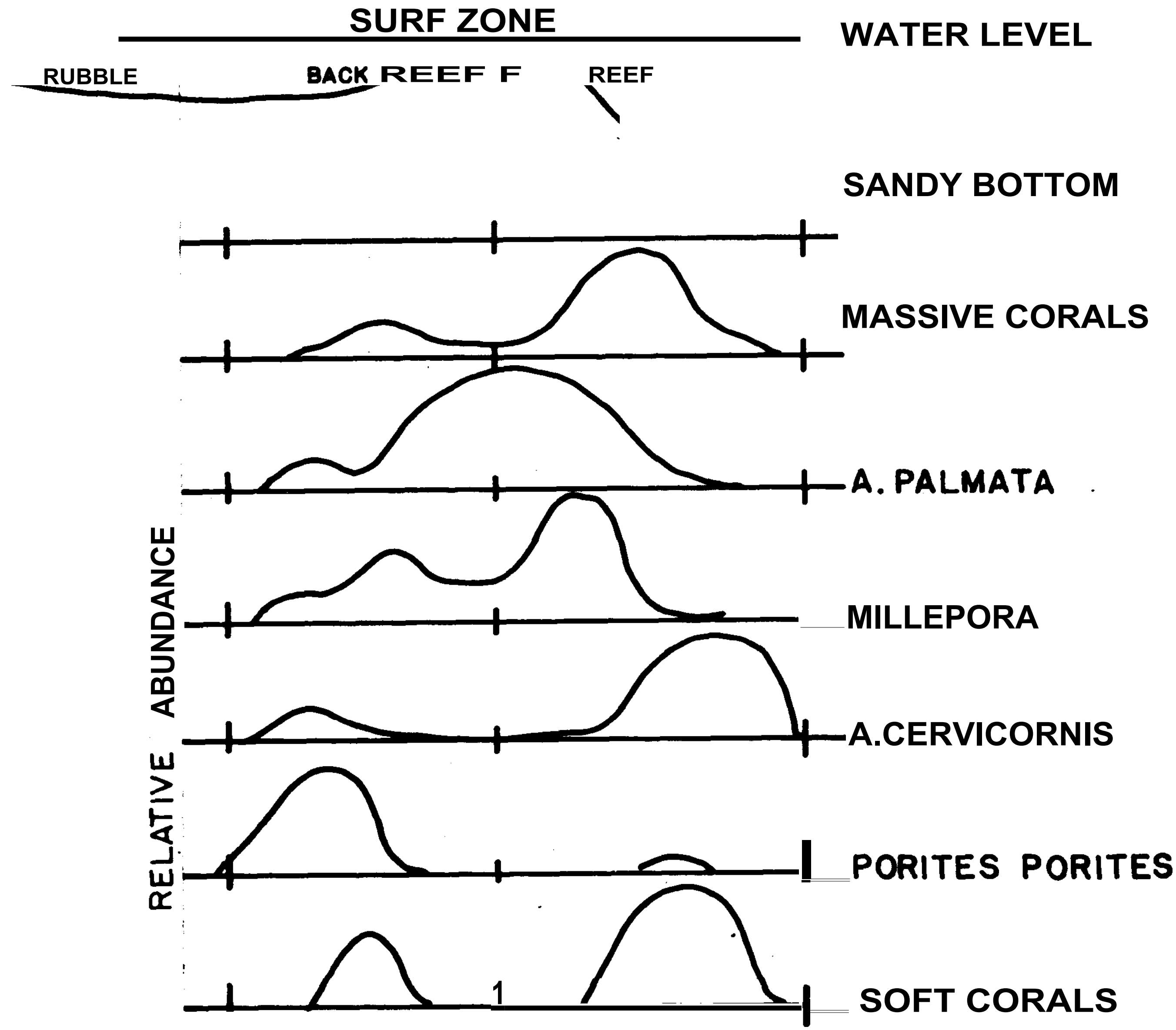


FIGURE 2. DIAGRAMMATIC PROFILE OF CORALS ACROSS REEF AT MARY CREEK

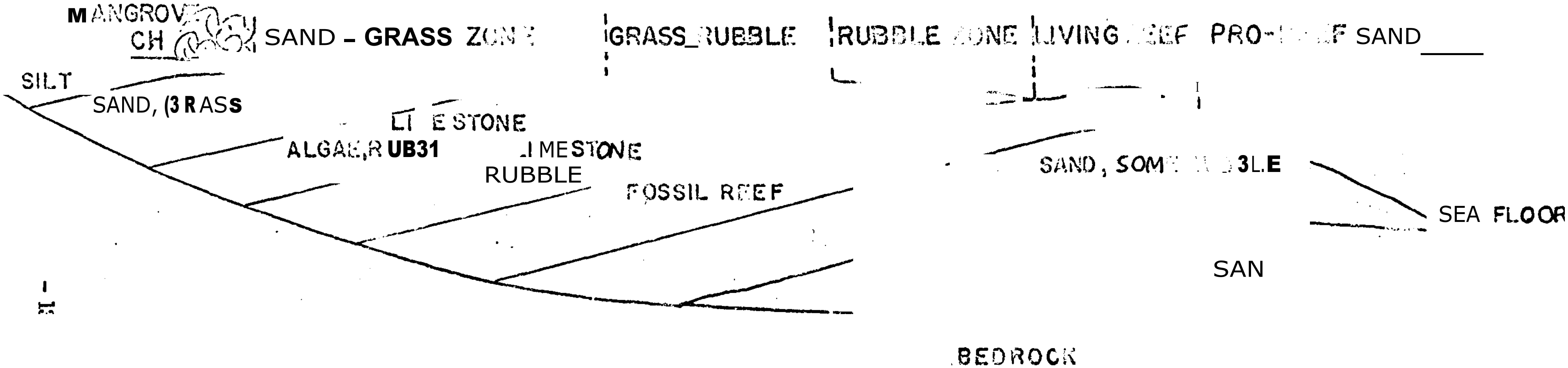
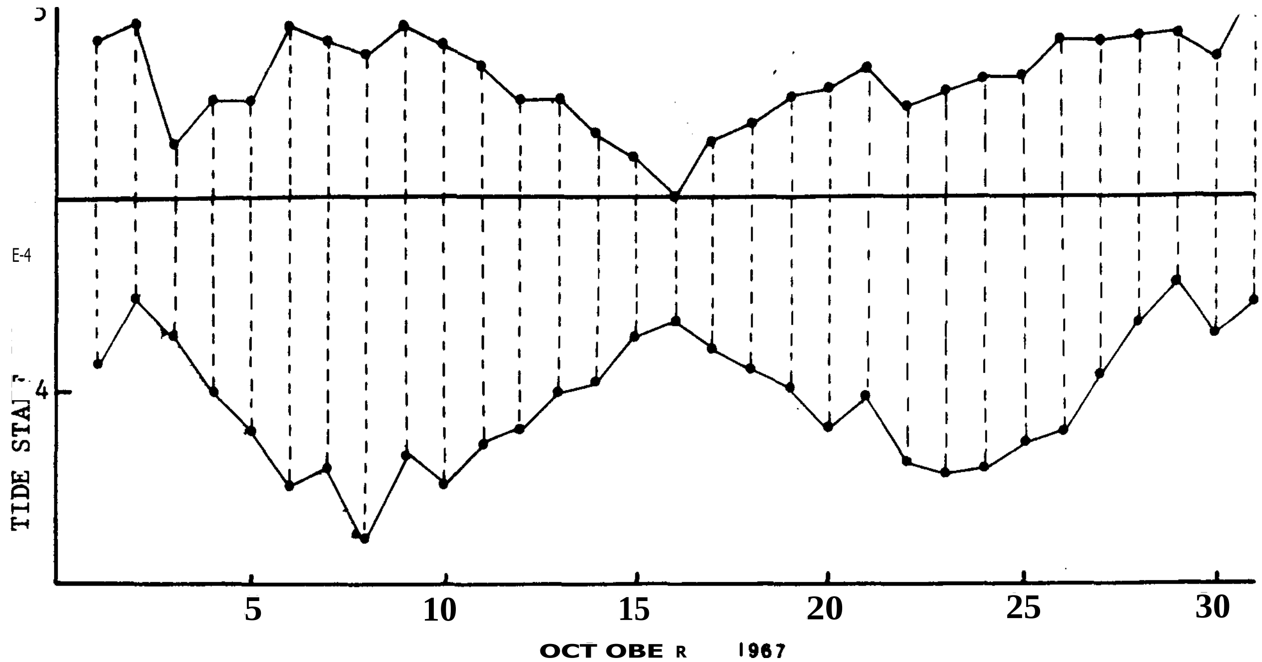
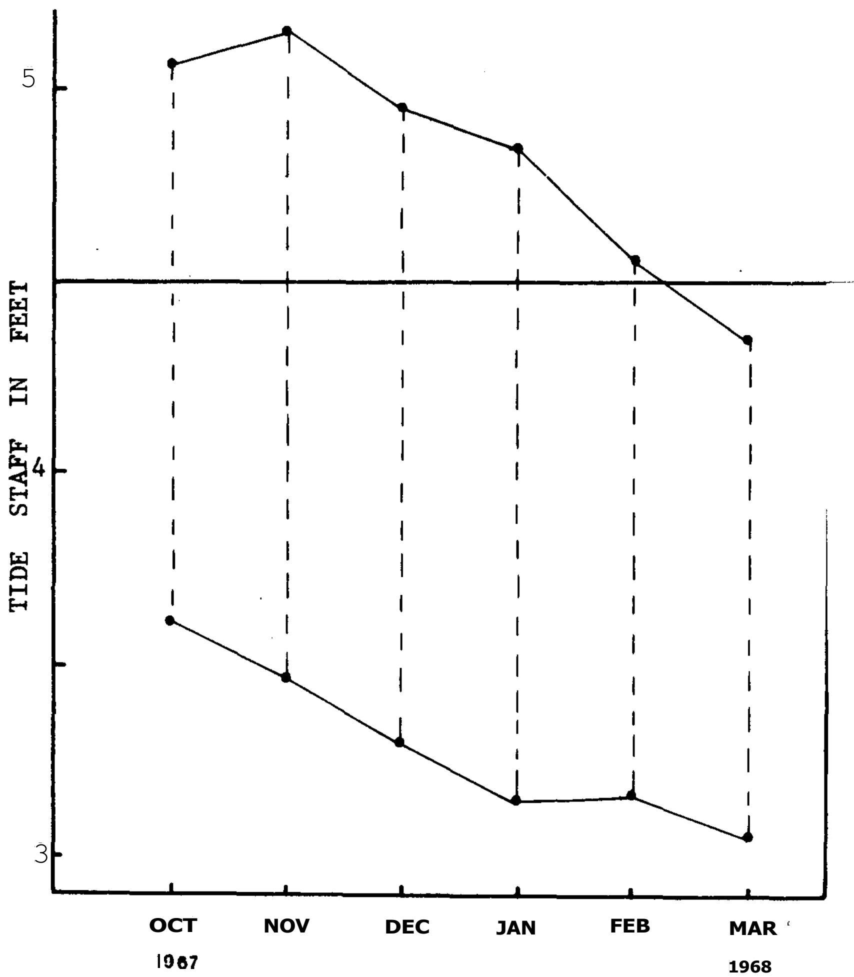


Figure 3. DIAGRAMMATIC CROSS SECTION OF MARY CREEK



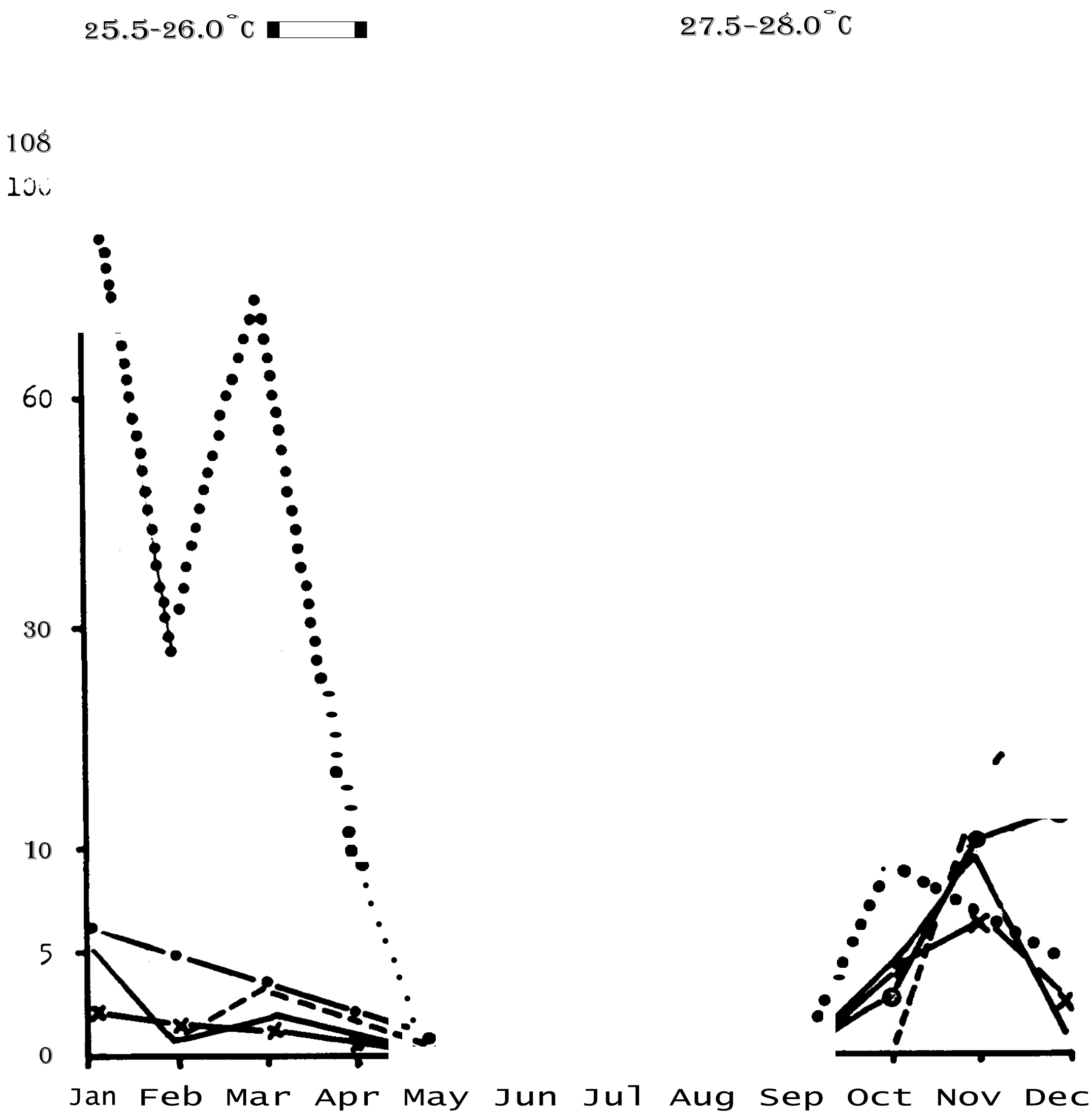


Mean High Water	0.70 ft
Mean Tide Level	0.35 ft
Mean Low Water	0000 ft

The estimated highest water level to the nearest half foot is 2 feet above mean low water. The estimated lowest water level to the nearest half foot is 1 foot below mean low water.

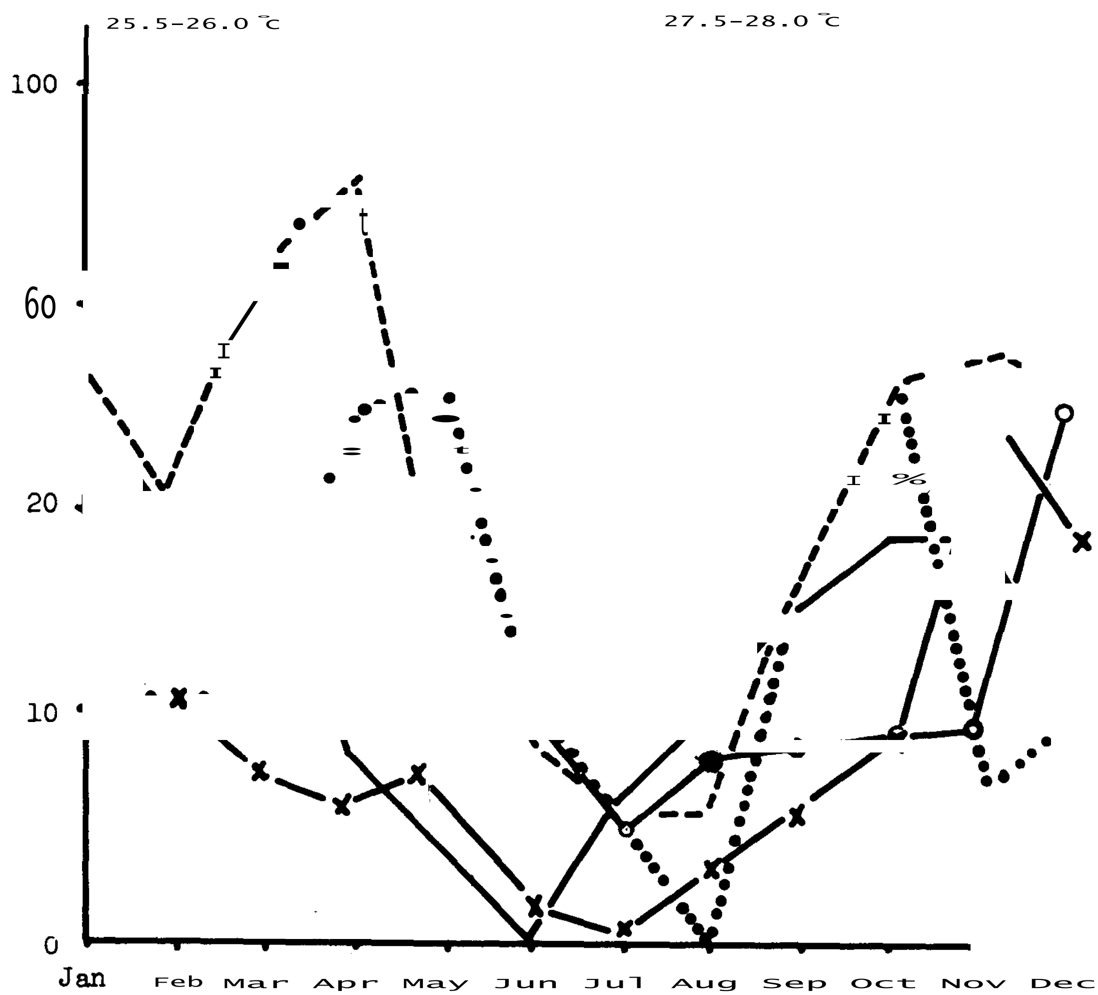
The tide at this location is chiefly diurnal

Graph 1 - TYPICAL TIDE PATTERNS AT LAMESHUR BAY



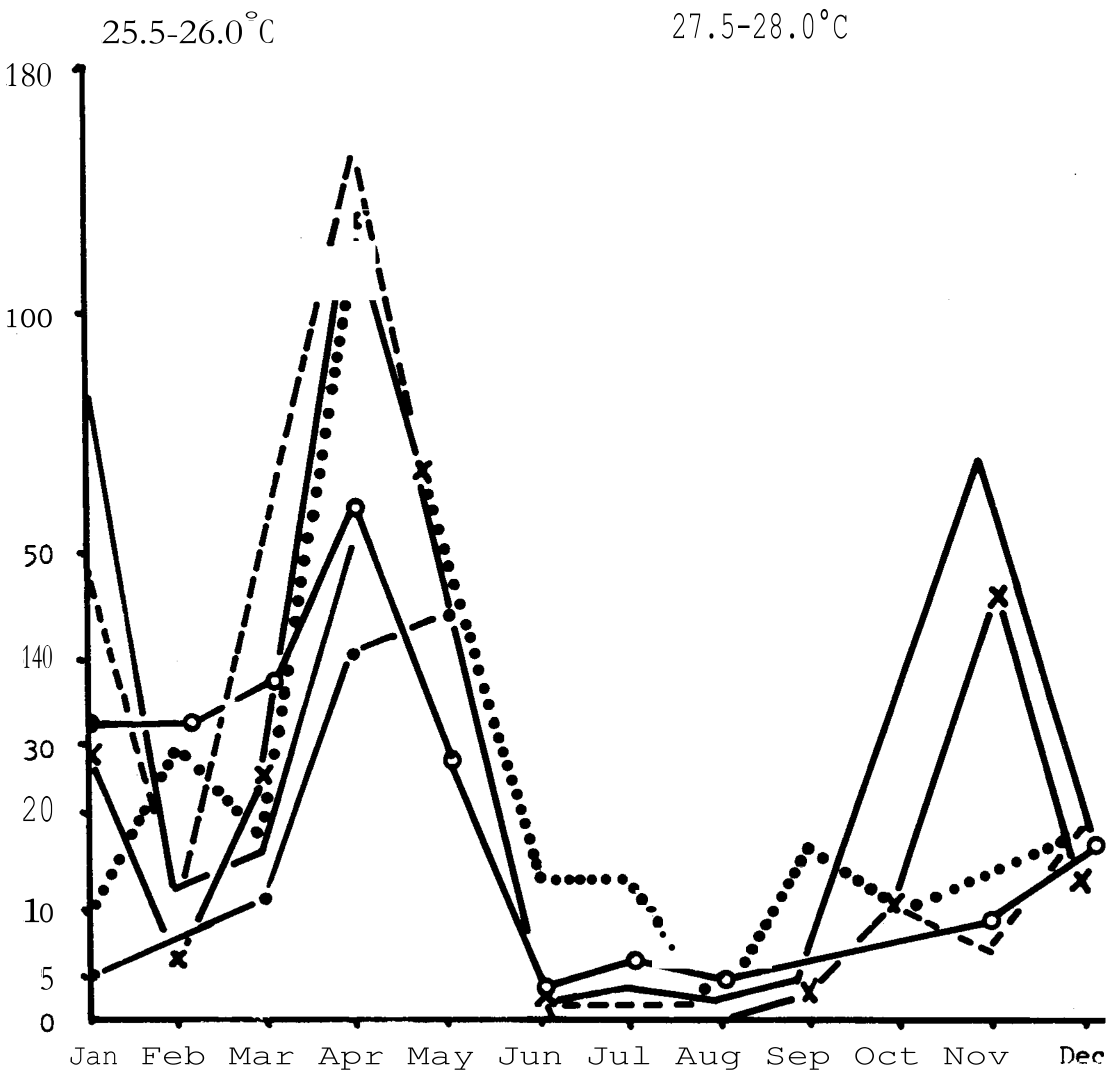
GRAPH NUMBER 2 Seasonal Catches of Sailfish

1964 1965 _ _ _ 1966 1967 0 ---0 1968 x---x 1969



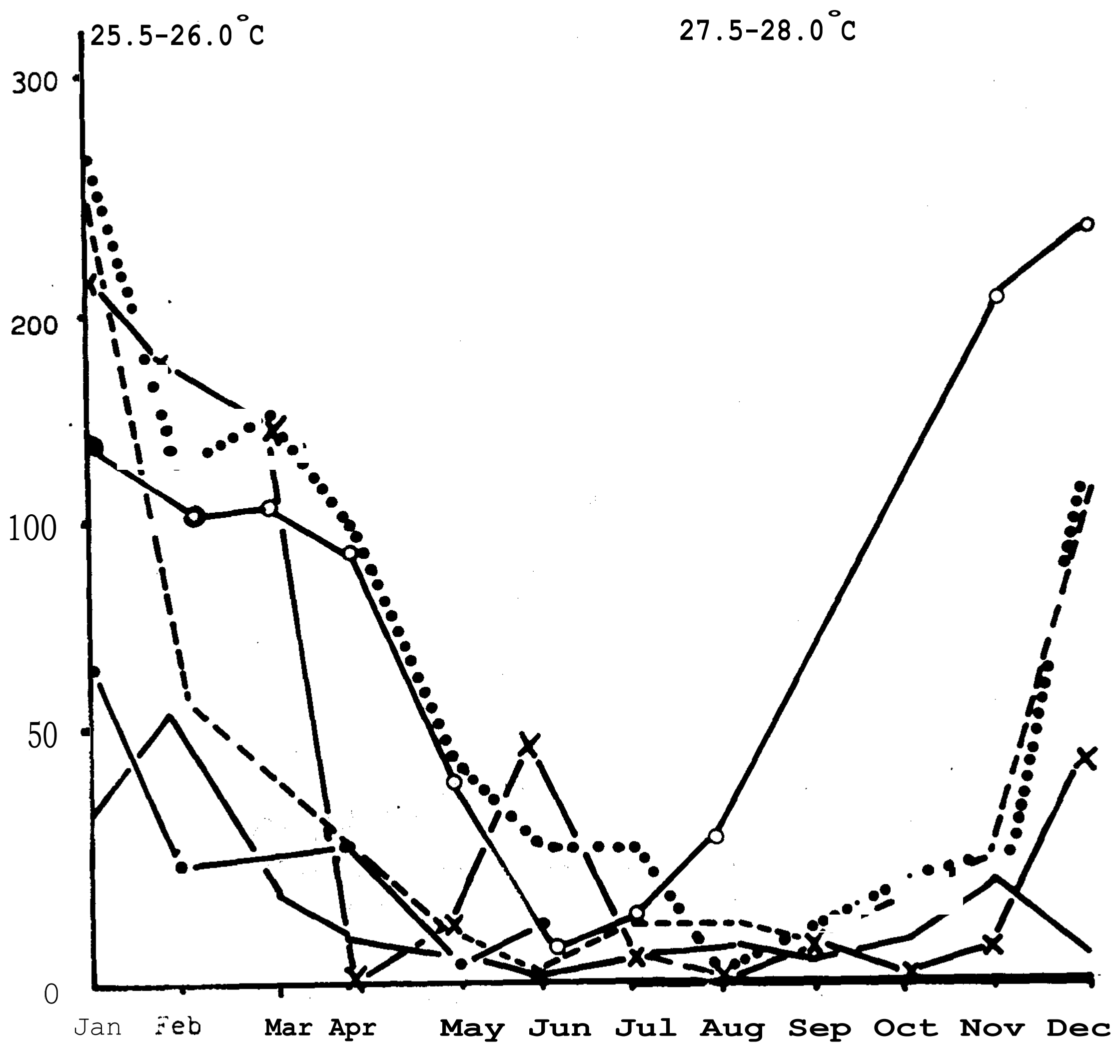
GRAPH NUMBER 3 Seasonal Catches of Wahoo

1964 1965_ 1966.......... 1967 0---0 1968 x---x 1969 ●— ●



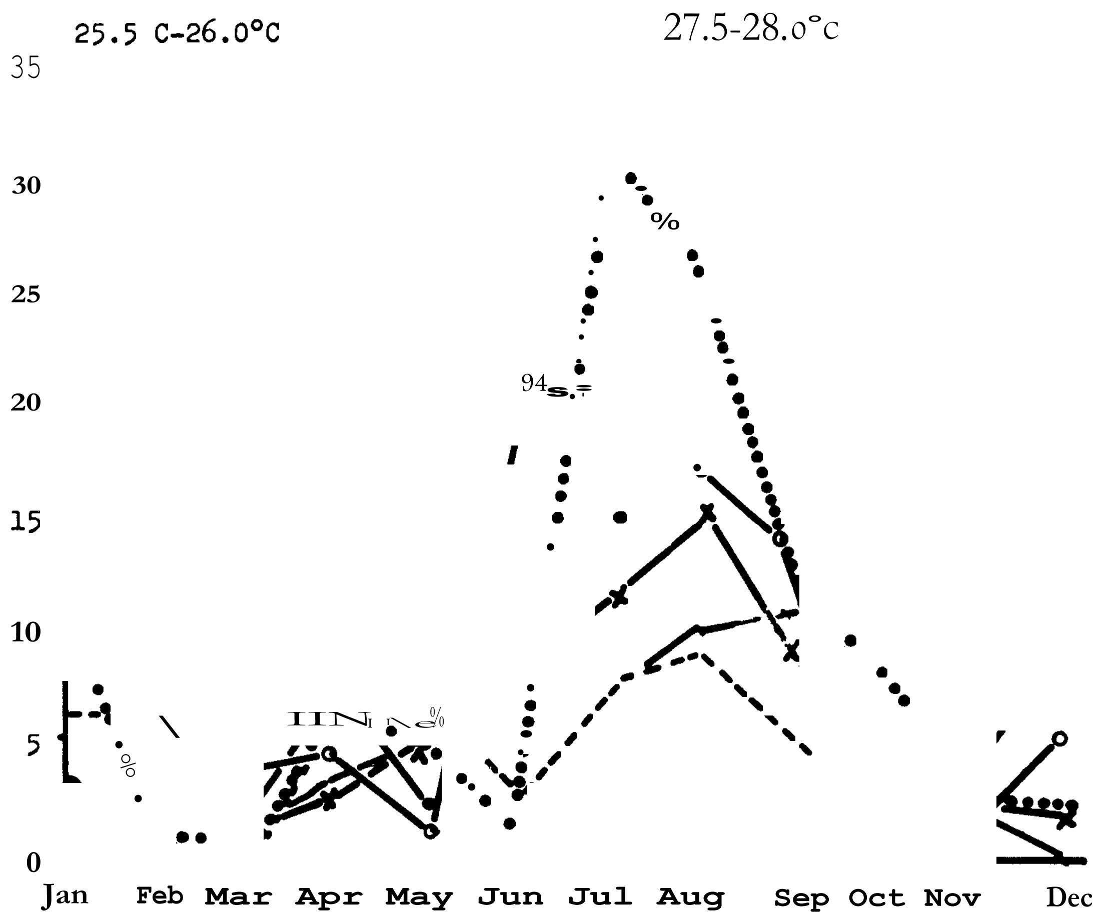
GRAPH NUMBER 4 Seasonal Catches of Dolphin

1964 ______ 1965 _ _ _ 1966 .... 1967 -0---0 1968 X---X 1969 ●—●



GRAPH NUMBER 5 Seasonal Catches of False Albacore

1964_____ 1965_ 1966....... 1967 o—o 1968 X X 1969



GRAPH NUMBER 6 **Seasonal Catches of Blue and White Marlin**

1964 1965 _ _ _ 1966 . . . . 1967 —0 1968 X X 1969 ●—●

Date	Hour	Sur-face temp	Reef temp	Sur-face O_2	Reef O_2	Sur-face salin-ity	Air temp	Wind	Weather
4-10-68	1300	25.8	25.8	9.1	8.7				----
	1500	25.8	25.8	8.2	7.9	29	28.5		
	1700	25.7	25.7	8.7	9.0	29	----		
	1900	25.0	25.5	8.325	8.1 5	29.8	22.5	10-12NE	Full moon, clear
	2100	25.0	25.5	8.4	8.0	29.5	21.5	7-10NE	Full moon, clear
	2300	25.0	25.5	7.60	7.50	29.5	21.75	10-15NE	Clear, some swells
4-11-68	0100	25.0	25.5	7.70	7.30	29.5	22.0	10-15NE	Clear, some swells
	0300	25.2	25.4	8.30	7.90	30.0	21.9	10-15NE	Clear, medium heavy swells
	0500	2 .8	25.0	7.90	7.70	30.5	21.2	10-15NE	Clear, moon set, slight swells
	0700	25.0	25.0	8.10	7.70	30.5	22.2	5-7NE	Bright sun
	0900	25.5	25.5	8.00	7.80	30.5	24.0	3-7NE	Bright sun
	1100	26.2	25.7	8.00	7.68	31.0	26.0	10-12NE	Bright sun, very clear

TABLE 1

WATER COLUMN CHARACTERISTICS over a 24 HOUR PERIOD

Location	*Daily* Carbon Fixation
Pillsbury Sound, St. John (Blue water)	8.9
Chocolate Hole, St. John (Shallow water)	10.3
Great Cruz Bay, St. John (Shallow water)	26.2
Mangrove Lagoon, St. Thomas (Shallow water)	80.6
Pineapple Bay, St. Thomas (Green flagellate Bloom)	126.4

TABLE 2

PRODUCTIVITY of SURFACE WATERS in SELECTED MARINE AREAS of the U.S. VIRGIN ISLANDS, determined in March, 1966. The results, determined with in situ methods, are expressed as mg C per cubic meter per day. Data of Burkholder and Dammann. Unpublished.

TABLE 3

Location	Carbon Fixation/Hour
Fish Bay, St. John	0.4
Magens Bay, St. Thomas	0.7
Botony Bay, St. Thomas	0.07
Hull Bay, St. Thomas	0.8
Coral Bay, St. John	2.3
Mangrove Lagoon, St. Thomas	6.1
Cruz Bay, St. John	24.6

CARBON ASSIMILATION of SOME SURFACE WATER SAMPLES COLLECTED in the VIRGIN ISLANDS and incubated in a flourescent incubator at about 5,000 foot candles. The data are expressed in mg C m^3 hr . March, 1966. Data of Burkholder and Dammann . Unpublished.

Depth in Feet	Carbon fixed	Chlorophyll A
Surface	8.9	0.28
15	6.1	0.37
30	11.1	0.39
45	9.7	0.37
60	9.3	0.34
75	6.8	0.45

TABLE 4

PRODUCTIVITY and CHLOROPHYLL in WATER at DIFFERENT DEPTHS of GREAT CRUZ BAY, St. John on April 1, 1966. Data are expressed as mg of carbon fixed per cubic meter per day. Chlorophyll is expressed as mg/m^3. Data of Burkholder and Dammann. Unpublished.

Name of Bay	Date	Intensity of Light (%)				
		1.6	10	20	60	100
Great Cruz	3/22/66	1.4	3.5	14.4	28.5	26.2
Mangrove Lagoon	3/23/66	2.3	22.6	37.6	78.9	80.9
Chocolate Hole	3/23/66	0.8	2.3	11.3	11.9	10.3
Pineapple Beach	4/2/66	5.2	43.8	103.9	118.9	126.4

TABLE 5

PRODUCTIVITY of SOME BAYS, U.S. VIRGIN ISLANDS, in relation to the varied intensity of daylight. Data are expressed as mg of carbon fixed per cubic meter of water per day. Data of Burkholder and Dammann. Unpublished.

	SUBSTANCE OR ORGANISM
13.4	Open detritus
26.6	Dead coral
1.2	Sand
1.8	Crevice
43.0	Non-living Material
0.2	Sponges
0.3	Gorgonians
0.7	Acropora palmata
3.3	Agaricia agaricites
0.1	Agaricia cucullata
1.9	Briarium spp.
0.8	Deploria labyrinthiformes
2.7	Millepora alcicornis
0.7	Millepora complanata
30.0	Montestrea annularis
1.5	Porites astreoides
14.3	Porites porites
0.2	Siderastrea siderea
56.7	Living Organisms
0.3	Miscellaneous and Unidentified
100.0	Total Surface Area Within Enclosure

Area of Reef O 098 acres

Volume or Reef...75 feet wide x 120 feet long x 30 feet high

The sea urchin Diadema antillarum had a density ranging from 3.63 to 8.0/square foot with a mean of 5.34, per square foot over the reef.

TABLE 6

SURFACE COMPOSITION of a VIRGIN ISLANDS REEF

Primary Frame Builders	
1. Diploria labyrinthiformis	(brain coral)
2. Diploria strigosa	(brain coral)
3. Diploria clivosa	(brain coral)
4. Montastrea annularis	(star coral)
Secondary Frame Builders	
1. Acropora palmata	(elkhorn coral)
2. Acropora cervicornis	(staghorn coral)
3. Millepora complanata	(fire coral)
Rigid Frames (Secondary), non-Builders	
1. Porites astreoides	(porous coral)
2. Siderastrea radians	(starlet coral)
3. Favia fagum	(star coral)
4. Dendrogyra cylindrus	(pillar coral)
5. Manicina areolata	(rose coral)
6. Isophyllia sinuosa	(cactus coral)
7. Agaricia agaricites	(flower coral)
Non-Rigid Frames	
1. Porites porites	(clubbed-finger coral)
2. Octa-corals	(fans, bushy types)
3. Lithothamnium	(algae)

TABLE 7

CLASSIFICATION of CORAL TYPES

Surf zone <u>corals</u> - fore-reef

1. Acropora **palmata**	**(most abundant)**	
2. Acropora cervicornis		
3. Diploria labyrinthiformis		
4. Diploria strigosa	(abundant with less wave action)	
5. Diploria clivosa	Parts of some large boulders	
6. Montastrea annularis	still living.	
7. Porites astreoides	(some)	
8. Millepora complanata **[Hydrozoan]**	(most abundant)	

<u>Below</u> surf zone - fore-reef

1. Diploria labyrinthiformis		
2. Diploria strigosa	Good number scattered along reef	
3. Diploria clivosa	front.	
4. Montastrea annularis		
5. Porites astreoides	(some)	
6. Porites porites	(some)	
7. Acropora palmata	(relatively abundant on upper slope)	
8. Acropora cervicornis	(patches)	
9. Siderastrea radians	(some)	
10. Octa-corals bushy types	(very abundant)	
11. Millepora complanata [Hydrozoan]	(abundant)	
12. Dendrogyra cylindrus	(some)	

<u>Behind</u> surf zone - Back reef

1. Porites porites	(large patches)	
2. Porites asteroids	(many small clumps)	Most
3. Siderastrea radians	(small in size)	abundant
4. Favia fagum	(small in size)	
5. Millepora **complanata**	(Hydrozoan)	
6. Acroposa palmata	(broken off branches)	
7. Acropora cervicornis	(small stubby branches)	
8. Montastrea annularis		
9. Diploria labyrinthiformis	Small living growths and	
10. Diploria strigosa	large dying ones with	
11. Diploria clivosa	sediment and algae on top.	
12. Dendrogyra cylindrus		
13. Manicina areolata		
14. Agaricia agaricites	A few	
15. Isophyllia sinuosa		
16. Octa-corals - bushy types and fans		

TABLE 8

LOCATION OF CORALS FOUND IN MARY CREEK

Surf zone and fore-reef	Calcification
1. **Porolithon**	heavy
2. Lithothamnium	heavy
3. Halimeda	heavy
Back-reef to sand-grass zone	
1. Lithothamnium	heavy
2. Galaxaura	heavy
3. Halimeda	heavy
4. Penicillus	light
5. Udotea	light

TABLE 9

LOCATION OF ALGAE TYPES FOUND IN MARY CREEK

FISH	J	F		A	M	J	J	A	S	O	N	D	TOTAL
Blue Marlin**							10	7	8				
White Marlin**				3	4		1	1			1		10
Sailfish									1		1	1	13
Wahoo	17	10	7	5	7	1		2	4	10	35	18	116
Allison Tuna	17	15	30	5	2	5	4	2	1	4	3	14	102
Dolphin	28	4	25	127	69				1	12	47	15	
Kingfish	23	50	40	20	19	34		4	3	4	4	9	210
Barra-cudas	53	22	64	33	55	41	7	17	12	39	25	19	[illegible]
False Albacore	210	175	128		9	46	4		10		8	37	627
Blackfin Tuna	21	14	93	28	21	84	30	21	30	48	22	71	48[illegible]
Mackerel (2 sp)	13	36	17	10	7	8		5	1	1		6	10[illegible]
Rainbow Runner	3	3		1	1			11	9	1	7	4	40
Sharks (? sp)	2	7	10	1		3	1	2	3	3	2	3	37
Bonito								8		12			•2
oceanic Bonito	5				2	12	4				12	2	37
Horse-eyed Jack	4				3	3		7					17
Grouper sp)		9	6		1							1	17
Bar Jack	3		1					3	1			2	10
Houndfish			2	3								1	6
Amberjack			3		1							1	5
Lizardfish	3												3
Yellowtail Snapper	1								1				2
Blackjack					1								1
24 species	406	345	428	236	202	237	61	90	85	140	171	206	2607
4P Days fished	29	18	30	28	17	18	20	29	19	21	21	23	
Average # Fish/Day	14	18.6	14.2	8.4	11.8	13.13		3.1	4.4	6.6	8.1	8.5	9.5
# of Angl-ers/day	3	3	3	3	3	3	3	3	3	3	3	3	3
Average # fish/angler/day	4.6	6.2	4.7	2.8	3.9	4.3	1	1	1.4	2.2	2.7	2.8	3.1

This is a 47 foot custom built sport fishermen operated by a resort hotel. Charter rates* are 2 people-$160; 3 people-$180; 4 people-$200; 5 people $210; 6 people-$2204The average for 5 other boats was 170 days each/year.
*Rates on all boats between 30 ft and 45 ft start at $150/day for two people and include crew, bait and tackle. Tips are extra.
**43.3% of the billfish were tagged and released.

TABLE 10

SUMMARY OF 1968 FISHING BY A VIRGIN ISLANDS CHARTER BOAT

WHITE	(Carcharodon carcharius).	inshore - offshore
MA KO	(Isurus oxyrinchus)	offshore
TIGER	(Galeocerdo cuvieri)	inshore - offshore
GREAT HAMMER HEAD	(Sphyrna mokkaran)	inshore - offshore
SCALLOPED HAMMERHEAD	(S[illegible])	inshore - offshore
BLUE	(Prionace glauca)	over deep water
LEMON	(Negaprion brevirostris)	inshore
BULL, CUB, GROUND	Carcharhinus leucas)	inshore
SPINNER, LARGE BLACKTIP	Carcharhinus maculipinnis)	inshore - offshore
SMALL BLACK TIP	(Carcharhinus limbatus)	inshore - offshore
DUSKY, CUB	(Carcharhinus obscurus)	inshore
SPRINGERS	(Carcharhinus springeri)	inshore - very common
WHITE TIP	(Carcharhinus longimanus)	inshore offshore
GALAPAGOS	(Carcharhinus galapagensis)	inshore - offshore
SILKY	(Carcharhinus falciformis)	offshore
BLACKNOSE	(Carcharhinus acronotus)	inshore - offshore
SAND	Carcharins taurus)	inshore
SHARPNOSE	(Rhizoprionodon porosus)	inshore
NURSE	(Ging lymostoma cirratum)	inshore - very common

TABLE 11

SHARK SPECIES OF THE VIRGIN ISLANDS

DATE	11 June 68			13 September 1968		
FAMILY	GENUS	SPC	INDIV	*GENUS*	SPC	INDIV
Clupeidae	1	1	1	0	0	0
Moringuidae	1	1	1	1	1.	1
Mureanidae	4	5	46	4	5	29
Xenogongridae	0	0	0	1	1	1
Belonidae	1	1	1	1	1	1
Anlostomiidae	1	1	2	1	1	4
Syngnathidae	1	2	2	0	0	0
Holocentridae	3	4	168	4	6	219
Serranidae	3	6	15	4	6	13
Grammistidae	1	4	23	1	2	5
Lutjanidae	T	1	1	2	2	32
Apogonidae	1	9	111	1	It	117
Carangidae	1	1	1	0	0	0
Priacanthidae	0	0	0	1	1	15
Pomodasyidae	1	2	37	1	1	523
Chaetodontidae	1	1	2	1	Z	5
Pomacentridae	4	7	314	4	8	102
Labridae	2	4	11	2	3	9
Sciaenidae	0	0	0	2	2	7
Mullidae	0	0	0	1	1	2
Scaridae	2	3	71	3	7	69
Acanthuridae	1	3	104	1	3	17
Dactyloscopidae	0	0	0	1	8.	1
Clinidae	3	3	19	1	2	4
Gobiidae	3	5	10	2	2	6
Scor.aenidae	2	2		0	[illegible]	0
Blenniidae	2			0	0	0
Brotulidae		3	20	3		
Atherinidae	2	2	5	1	1	23
Bothidae	1	1	[illegible]	0	0	0
Balistidae	1	1	3	1	1	3
Ostraciidae	1	1	1	1	1	1
Tetradontidae	1	1	6	2	2	22
Lobster	1	1	3	1	1	3
Octopus	0	–	0	1	1	1

TABLE 12

EFFECTS OF POISONING ON THE TAXONOMIC COMPOSITION OF REEF FISH POPULATIONS

	4/25/68 gen/sp/spec/	Total wt.	4/30/68	Total wt.	5/288 gen/sp/spec/	Total wt.	s 3 88 gen/sp spec/	Total wt.	5 9 fie gen sp/ spec/	Total wt.	Poisoned 6/11/68 5/16/6 gen/sp/spec	Total Wt.	7/2/88 n/sp/	Total	Poisoned 9/13/08 TOTALS	Total wt.				ma	
Panuliridae															1/1/3	624.9		131.1	277.9 /170	120	220
(1) Panulirus									x/1/3	624.9								[illegible]	277.9/170	120	220
P.									x/x/3	624.9											
Holocentridae	1/1/11	549.1			3/3/9	468.	1/1/4	320.	1/10	700.4		74.5			3/3/35	2112.5	1	18.3	109.8/180	140	220
(1)mom					x/1/1	8.4									x/1/1	8.4		—	— —	—	—
A. coruscus					x/x/1	8.4									x/x/1	8.4		---	— ---	---	---
(2) olocentrus	I				x/1/6	344.4			/1(	[illegible]0.4		74.5			x/1/32	1988.8		18.3	109.8/180	140	220
H. rufus	x/x/11	549.1			x/x/6	344.4	x/x/4	320.4			x/x/1	74.5			x/x/32	1988.8		18.3	109.8/180	140	220
(2)M [illegible]					x/1/2	115.3									x/1/2	115.3	57.6	43.3	72.0 152	140	165
M					2	115.									x/x/2	115.3	57.6	43.3	72.0/152	140	165
Serranidae					1/1/1	293.	1/1/1	496.	[illegible]		1/1/1	274.0			3/3/5	1266.1	82.4	68.2	496.6/250	206	294
(1) Cenl ..., .									x/1/2	202.					x/1/2	202.	,2	68.2	134.2/205	206	205
C. fulva															x/x/2	202.4	01.2	68.2	134.2/205	205	205
(2) Epinephelus					1/1	293.									x/1/1	293.1	--	—	— - —	—	—
E. guttatus					1	293.									x/x/1	293.1	---				—
(3) Petromeptopor							/1/1	496.				274.0			x/1/2	[illegible]	385.3	274.0	[illegible]		294
P. cruentatum							1	496.			x/x/1	274.0			W2	770.6		274.0 4	6/280	265	294
I anidae				-											1/1/1	37.2		---	--- —	—	--
(1) Ocyurus			1/1	37.2											x/1/1	37.2					[illegible]
O. chrysurus			x/1	37.2											x/x/1	37.2		—	— —	—	—
	1/1/7	333.1	/45	2873.1					1/3/37	2486.7			1/1/12	737.8	1/4/130	8484.4		18.6	113.1/170	130	210
(1) Haemulon	7	333.1	45	2873.1		1969.1			3 37	2486.7			x/1/12	737.8	x/4/130	8484.4	65.8	18.6	113. 170	130	210
H. aurolineatum									x/x/15	949.3					x/x/24	1520.9	72.8	34.0	111.5/178	150	207
H. carbonarium															x/x/1	67.7					
H. ch [illegible]			x/x/4	312.4					x/x/5	420.8					x/x/23	1872.1	74.4	35.8	113.1/17	147	210
• H. flavolineatum	7	333.1	41	2560.7	x/x/5	275.5							x/x/12	737.8	x/x/32	5023.7	58.8	18.6	99.1/162	130	195
Sciaenidae					1/1/1	54.0									1/1/1	54.0	---	---	— ---	---	---
(1) Odontoscion					x/1/1	54.0									x/1/1	54.0	—	—	— —	—	—
O. dentex					1	54.0									x/x/1	54.0	---	---	--- —	—	
Pomacentridae			[illegible]/1		2 2 13	438.6					/2/2	97.0			17W740	1592.1	47.0	13.0	81.1 118	80	156
(1) Chromis															x/2/15	513.7	32.2	21.0	43.5 132	120	145
C																	—		—	—	—
C. multilineata									14	476.5					x/x/14	476.5	32.2	21.0	43.5 82	120	145
(2) Eupomacentrus							3	54.			x/1/1	25.3			x/2/13	237.1	24.4	13.0	35.7 95	80	110
E. leucostictus							3	54.4			x/x/1	25.			/x/4	79.7		[illegible]	[illegible]	83	10[illegible]
E. planifrons					x/x/9																
(3) Microspathodon			1/2	161.3	x/1/4	281.2	x/1/2	123.	x/1/3	204.0	x/	71.7			x/1/12	841.3	69.3	57.5	81.1 / 145	134	156
M. chrysurus			2	161.3			x x/2	123.1	3	204.0	x/x/1	71.7			x/x/12	841.3	69.3	57.5	81.1 145	134	156
TOTALS		888 2		3071				116.3		4070.0		445.5		737.8		13,546.3	---	13.0	496.6/ —	80	294
	2 families		families		5 families		4 families		4 families		families										
	2										4 genera										
													1 species								
											specimens		a specimens								

TABLE 13

SUMMARY OF FISH TAKEN IN POTS FROM A CONTROLLED REEF

	#gen	#sp	#spec	Total wt..	Mean wt..	Mean lgt.	RANGE WT. G. small	large	RANGE LGT. UN. small	large
1. Clupeidae	1	1	3	Tr			Tr	Tr	25	28
(1) Jenkinsia		1	3	Tr			Tr	Tr	25	28
J. lamprotaenia			3	Tr			Tr	Tr	25	28
2. Moringuidae	1	1	2	11.4	5.7	297	4.6	6.8	287	307
(1) Moringua		1	2	11.4	5.7	297	4.6	6.8	297	307
M. edwardsi			2	11.4	5.7	297	4.6	6.8	297	307
3. Muraenidae	4	5	46	2451.2			1.1	606.5	105	690
(1) Echidna		1	1	372.3						
E. catenata			1	372.3						
(2) Enchelycore		2	31	249.2			1.1	20.4	105	310
E. nigricans			30	248.1	8.5	212	1.4	20.4	110	310
E. sp (Chestnut Moray)			1	1.1						
(3) Gymnothorax		1	4	1095.5	273.9	528	37.8	606.5	310	690
G. moringa			4	1095.5	273.9	528	37.8	606.5	310	690
(4) Muraena		1	10	734.2	80.9	313	2.1	210.0	150	460
M. miliaris			10	734.2	80.9	313	2.1	210.0	150	460
4. Belonidae	1	1	1	11.7						
(1) Platybelone		1	1	11.7						
P. argala			1	11.7						
Aulostomidae	1	1	2	75.8	37.9	305	27.8	48.0	285	325
(1) Aulostomus		1	2	75.8	37.9	305	27.8	48.0	285	325
A. maculatus			2	75.8	37.9	305	27.8	48.0	285	325
6. Syngnathidae	1	2	2	1.0			0.4	0.6	105	110
(1) Syngnathus		2	2	1.0			0.4	0.6	105	110
S. sp. #1			1	0.6						
S. sp. #2			1	0.4						

TABLE 14

SUMMARY OF FISH POISONED FROM A CONTROLLED REEF ON JUNE 11, 1968

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	RANGE WT. G. large	RANGE LG small	RANGE LG large
7. Holocentridae	3	4	168	8246.7			5.0	101.0	70	228
(1) Holocentrus		2	155	7756.5			11.9	101.0	105	228
H. ascensionis			4	289.0	72.3		63.0	88.0	195	206
H. rufus			151	7467.5	49.4	178	11.9	101.0	105	228
(2) Myripristis			9	381.5	42.4	129	5.0	86.0	105	228
M. jacobus			9	381.5	42.4	129	5.0	86.0	70	169
(3) Plectrypops		1	4	108.7	27.2	96	10.6	43.0	71	120
P. retrospinis			4	108.7	27.2	96	10.6	43.0	71	120
8. Serranidae	3	6	15	443.6			4.2	164.7	59	215
(1) Chorististium		1	5	26.9			4.2	6.6	59	79
C. rubre			5	26.9	5.4	68	4.2	6.6	59	79
(2) Hypoplectrus		4	8	182.3			7.8	38.0	78	131
H. aberrans			1	20.6	----	---	----	-----	---	---
H. nigricans			5	136.9	27.4	116	16.7	38.0	101	131
puella			1	17.0	----	---	----	-----	---	---
H. puella/unicolor (hybrid)			1	7.8	----	---	----	-----	---	---
(3) Petrometopon		1	2	234.4			69.7	164.7	165	215
P. cruentatum			2	234.4	117.2	190	69.7	164.7	165	215
9. Grammistidae	1	4	23	427.8			2.5	77.0	60	175
(1) Rypticus		4	23	427.8			2.5	77.0	60	175
R. sp. #1			3	21.0			6.0	8.4	82	95
R. Sp. #2			2	5.9			2.5	3.4	60	66
R. saponaceus			11	366.6	33.3	127	4.2	77.0	75	175
R. ubbifrenatus			7	34.3	4.9	78	4.0	5.8	72	81
Lutjanidae	1	1	1	55.5						
(1) Ocyurus		1	1	55.5						
O. chrysurus			1	55.5						

TABLE 14 (Cont'd)

		#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	RANGE WT. G. large	RANGE LGT. CM. small	RANGE LGT. CM. large
11	Apogonidae	1	9	111	259.7			0.1	5.3	30	82
	(1) Apogon		9	111	259.7			0.1	5.3	30	82
	A. binotatus			1	0.5						
	A. conklini			59	138.8	2.4	49	0.1	4.7	30	59
	A. maculatus			20	68.9	3.4	68	0.9	4.9	53	76
	A. phenax			1	0.8	---	---			--	
	A. pigmentarius			17	17.8	1.1	47	0.4	2.1	35	60
	A. planifrons			1	5.3	---				--	
	A. robinsi			2	1.0	0.5	31.5	0.5	0.5	31	32
	A. townsendi			1	1.8	---					
	A. (sp. unknown)			9	24.8	2.8	66	1.1	1.1	52	82
12.	Carangidae	1	1	1	5.0						
	(1) Caranx		1	1	5.0						
	C. ruber			1	5.0						
	Pomadsyidae	1	2	37	2241.7			22.7	106.1	120	205
	(1) Haelmulon		2	37	2241.7			22.7	106.1	120	205
	H. chrysargyreum			22	1426.8	64.9	171	22.7	106.1	120	205
	R. flavolineatum			15	814.9	54.3	157	31.0	100.2	134	185
•.	Chaetodotidae	1		2	56.0	18.0	99	25.1	31.0	95	103
	(1) Chaetodon			2	56.0	18.0	99	25.1	31.0	95	103
	C. capistratus			2	56.0	18.0	99	25.1	31.0	95	

TABLE 14 (Cont'd)

	#[illegible]	#sp.	#[illegible]	T[illegible]	M[illegible]	M[illegible]	RANGE WT. G.		RANGE	LGT. CM.
15. P[illegible]	4	7	314	3244.0			0.6	74.4	40	145
(1) A[illegible]		1	1	22.5						
A. [illegible]			1	22.5						
(2) Chromis		2	2	76.1			15.1	61.0	110	115
cyanea			1	61.0						
C. [illegible]			1	15.1						
(3) Eupc ntrus		3	300	2662.6			0.9	28.6	40	110
E. leucostictus			22	62.4	2.8	56	0.9	7.6	40	77
L. [illegible]			42	302.9	7.2	72	1.9	20.1	46	100
E. [illegible]			236	2297.3	9.7	50	1.0	28.6	40	110
(4) Micr athodon		1	10	482.8			0.6	74.4	60	145
M. chrysurus			10	482.8	48.3	124	0.6	74.4	60	145
16. L[illegible]	2	4	11	24.8			0.5	10.3	36	100
(1) H[illegible]		3	9	23.8			0.6	10.3	43	100
H. [illegible]			2	16.0	8.0	90	5.7	10.3	80	100
H. maculipinna			4	4.7	1.2	49	0.9	1.6	45	57
H. [illegible]			3	3.1	1.0	48	0.6	1.3	43	51
(2) Thalassoma		1	2	1.0			0.5	0.5	36	41
T. [illegible]			2	1.0	0.5	39	0.5	0.5	36	41
1[illegible]. S[illegible]	2	3	71	1166.9			0.4	153.8	35	190
(1) S[illegible]		2	61	660.7			0.6	27.0	40	115
S. [illegible]			26	265.3	10.2	80	0.6	24.3	40	111
S. taeniopterus			35	395.4	11.3	89	6.5	27.0	75	115
(2) Sparisoma		1	10	506.2			0.4	153.8	35	190
S. viride			10	506.2	50.6	111	0.4	153.8	35	190

TABLE 14 (C[illegible])

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	large	RANGE LGT. CM. small	large
18. **Acanthuridae**	**1**	3	104	1697.2			0.7	59.5	35	155
(1) Acanthurus		3	104	1697.2			0.7	59.5	35	155
A. bahrius			64	1207.3	18.7	98	1.4	59.5	37	155
A. chirurgus			17	383.6	22.6	106	11.2	**38.4**	87	127
A. coeruleus			23	106.3	4.6	52	0.7	44.9	35	130
19. Gobiidae	3	5	10	6.3			Tr	1.5	24	60
(1) Coryphopterus		3	8	5.6			0.4	1.5	32	60
C. dicrus			2	1.1	0.6	39	0.4	0.7	35	42
C. glaucofraenum			5	4.2	0.8	43	0.4	1.5	32	60
C. haulinus			1							
(2) Gnatholepis		1	1	0.7						
G. thompsoni			1	0.7						
(3) Gobiosoma		1	1	Tr						
G. evelynae			1	Tr			---			
20. Scorpaenidae	2	2	13	81.3			1.8	34.5	50	115
(1) Scorpaena		1	2	37.6	18.8	85	3.1	34.5	55	115
S. plumieri			2	37.6	18.8	85	3.1	34.5	55	115
(2) Scorpaenodes		1	11	43.7	3.9	61	1.8	6.6	50	75
S. caribbaeus			11	43.7	3.9	61	1.8	6.6	50	75
21. Clinidae	3	3	19	37.0			0.1	4.9	29	77
(1) Labrisomus		1	6	20.1	3.3	64	2.7	4.9	66	77
L. nuchipinnis			6	20.1	3.3	64	2.7	4.9	66	77
(2) Malacoctenus		1	11	16.6	1.5	52	0.4	2.6	35	66
M. triangulatus			11	16.6	1.5	52	0.4	2.6	35	66
(3) Starksia		1	2	0.3	0.15	30	0.1	0.2	29	31
S. **lepicoelia**			2	0.3	0.15	30	0.1	0.2	29	31

TABLE 14 (Cont'd)

		#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	large	RANGL LGT. small	large
22.	Blenniidae	2	2	7	18.5			1.6	3.6	61	80
	(1) Blennius		1	1	2.3						
	B. sp.			1	2.3						
	(2) Ophioblennius		1	6	16.2	2.7	69	1.6	3.6	61	80
	O. atlanticus			6	16.2	2.7	69	1.6	3.6	61	80
23.	Brotulidae	3	3	20	45.9			0.2	7.8	29	97
	(1) Ogilbia		1	13	22.1	1.7	56	0.2	7.3	29	90
	O. cayorum			13	22.1	1.7	56	0.2	7.3	29	90
	(2) Oligopus		1	1	1.6						
	O. claudei			1	1.6						
	(3) Petrotyx		1	6	22.2	3.7	73	1.1	7.8	55	97
	P. sanguineus			6	22.2	3.7	73	1.1	7.8	55	97
	Atherinidae	2	2	5	6.5			0.9	1.5	55	65
	Allanetta		1	1	1.5						
	A. harringtonensis			1	1.5						
	(2) Atherinomorus		1	4	5.0	1.2	61	0.9	1.4	55	65
	A. stipes			4	5.0	1.2	61	0.9	1.4	55	65
25.	Bothidae	1	1	1	5.6						
	(1) Bothus		1	1	5.6						
	B. linatus			1	5.6						

TABLE 14 (Cont'd)

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	RANGE WT. G. large	RANGE LGT. CM. small	RANGE LGT. CM. large
26. Balistidae	1	1	3	22.0	7.1	73	2.9	13.0	58	89
(1) Cantherines		1	3	22.0	7.1	73	2.9	13.0	58	89
C. pullus			3	22.0	7.1	73	2.9	13.0	58	89
27. Ostraciidae	1	1	1	5.5						
(1) Lactophrys		1	1	5.5						
L. triqueter			1	5.5						
28. Tetraodontidae	1	1	6	33.1	5.5	59	2.7	7.8	52	67
(1) Canthigaster		1	6	33.1	5.5	59	2.7	7.8	52	67
C. rostrata			6	33.1	5.5	59	2.7	7.8	52	67
SUMMARY	49	75	999	20,682.7			Tr	606.5	24	690

(TABLE 14 (Cont'd)

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	RANGE WT. G. large	RANGE LGT. CM. small	RANGE LGT. CM. large
1. Octopodidae	1	1	2	104.0	55	243	6.5	103.5	154	332
(1) Octopus		1	2	104.0	55	243	6.5	103.5	154	332
O. sp.		1	2	104.0	55	243	6.5	103.5	154	332
2. Panuliridae	1	1	3		688.9	275	274.5	1103.4	98	450
(1) Panulirus		1	3		688.9	275	274.5	1103.4	98	450
P. argus		1	3		688.9	275	274.5	1103.4	98	450
3. Synodontidae	1	2	2	37.6	18.8	134	2.9	34.7	85	183
(1) Synodus		2	2		18.8	134	2.9	34.7	85	183
S. foetens			1	2.9						
S. intermedius			1	34.7						
4. Moringuidae	1	1	2	7.1	3.5	265	3.1	4.0	240	290
(1) Moringua		1	2	7.1	3.5	265	3.1	4.0	240	290
M. eduardsi			2	7.1	3.5	265	3.1	4.0	240	290
3. Xenocongridae	1	1	1	8.1						
(1) Kavpichthys		1	1	8.1						
K. hyeproroides			1	8.1						
6. Muraenidae	4	5	19	2329.75	360.2	436	2.4	718.0	146	725
(1) Echidna		1	1	30.5						
E. catenata			1	30.5						
(2) Enchelycore		1	6	74.9	26.8	263	2.4	51.3	146	380
E. nigricans			6	74.9	26.8	263	2.4	51.3	146	380
(3) Gymnotherax		2	10	2057.25	364.2	481	10.4	718.0	237	725
G. moringa			9	2057.2	364.2	481	10.4	718.0	237	725
d. vicinus			1	0.05		---				
(4) Muraena		1	2	167.1	83.5	374	71.0	96.1	363	386
I. miliaris			2	167.1	83.5	374	71.0	96.1	363	386

TABLE 15

SUMMARY OF FISH POISONED FROM CONTROLLED REEF ON SEPTEMBER 13, 1968

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	RANGE WT. G. large	RANGL LGT. CM. small	RANGL LGT. CM. large
7. Belonidae	1	1	1	5.0						
(1) Platybelone		1	1	5.0						
P. argala			1	5.0						
8. Aulostomidae	1	1	4	325.7	64.1	364	24.2	104.0	278	450
(1) Aulostomus		1	4	325.7	64.1	364	24.2	104.0	278	450
A. maculatus			4	325.7	64.1	364	24.2	104.0	278	450
9. **Holocentridae**	4	6	219	8882.1	115.0	150	0.7	229.2	41	260
(1) Adioryx		2	32	416.8	16.8	88	0.7	32.9	41	135
A. coruscus			14	79.4	8.2	76	0.7	15.6	41	110
A. **vexillarius**			18	337.4	18.8	102	4.6	32.9	70	135
(2) Holocentrus		2	169	7722.9	115.2	152	1.2	229.2	45	260
H. ascensionis			3	231.6	115.2	152	1.2	229.2	45	260
H. **rufus**			166	7491.3	58.5	170	13.5	103.5	105	235
(3) **Myripristis**		1	17	729.7	66.8	140	10.0	123.6	85	195
M. **jacobus**			17	729.7	66.8	140	10.0	123.6	85	195
(4) Plectrypops		1	1	12.7						
P. retrospinis			1	12.7						
10. Serranidae	4	6	13	1328.0	167.5	181	1.3	333.7	52	310
(1) Epinephelus		2	2	613.9	306.9	372	126.5	487.4	325	420
E.adscensionis			1	487.4						
E. striatus			1	126.5						
C2) ffypoplectrus		2	6	90.2	19.0	98	3.0	35.0	62	135
H. nigricans			2	62.0	31.0	80	27.0	35.0	125	135
H. puella			4	28.2	7.8	78	3.0	12.5	62	93
(3) Mycteroperc,		1	2	618.0	309.0	298	284.3	333.7	285	310
M. venenosa bonaci			2	618.0	309.0	298	284.3	333.7	285	310
(4) Serranus		1	3	5.9	1.8	62	1.3	2.3	52	72
S. tigrinus			3	5.9	1.8	62	1.3	2.3	52	72

TABLE 15 (Cont'd)

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT, G. small	large	RANGE LGT. CM. small	large
11. Grammistidae	1	2	5	148.0	32.2	125	4.5	60.0	75	175
(1) Rypticus		2	5	148.0	32.2	125	4.5	60.0	75	175
R. saponaceus			4	143.5	34.3	135	8.6	60.0	95	175
R. subbifrenatus			1	4.5						
12. Lutjanidae	2	2	32	1566.3	140.1	178	8.2	272.0	95	260
(1) Lutjanus		1	2	411.7	205.4	240	138.7	272.0	220	260
L. apodus			2	411.7	205.4	240	138.7	272.0	220	260
(2) Ocyurus		1	30	1154.6	67.1	164	8.2	126.0	95	233
O. chrysurus			30	1154.6	67.1	164	8.2	126.0	95	233
13. Priacanthidae	1	1	15	755.1	106.6	160	5.4	207.7	81	240
(1) Priacan-thus		1	15	755.1	106.6	160	5.4	207.7	81	240
P. cruentatus			15	755.1	106.6	160	5.4	207.7	81	240
14. Apogonidae	1	4	117	185.3	3.4	56	0.1	6.6	20	92
(1) Apogon		4	117	185.3	3.4	56	0.1	6.6	20	92
A. conklini			3	1.8	0.6	42	0.4	0.9	31	53
A. maculatus			4	11.7	3.3	69	2.2	4.4	61	77
A. phenax			109	168.4	3.4	56	0.1	6.6	20	92
A. planifrons			1	3.4						
15. Pomadasyidae	1	7	523	17492.7	167.5	180	1.4	333.6	60	300
(1) Haemulon		7	523	17492.7	167.5	180	1.4	333.6	60	300
H. aurolineatum			244	9553.0	50.8	155	8.1	93.5	110	200
H. carbonarium			1	301.5						
H. chrysargyreum			1	31.7						
H. flavolineatum			269	7022.3	51.2	145	6.4	96.0	95	195
H. plumieri			5	191.4	55.8	158	23.2	88.4	125	190

TABLE 15 (Cont d)

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt	RANGE WT. G. small	large	RANGE LGT. CM. small	large
(continued)										
(15) Pomadasyidae										
H. Sciurus			2	391.4	195.7	232	57.8	333.6	165	300
H. steindachneri			1	1.4		---		---		
16. Sciaenidae	2	2	7	156.3	21.6	124	1.5	41.8	80	168
(1) Equetus		1	2	3.3	1.6	82	1.5	1.8	80	85
E. punctatus			2	3.3	1.6	82	1.5	1.8	80	85
(2) Odontoscion		1	5	153.0	33.9	152	26.0	41.8	135	168
O. dentex			5	153.0	33.9	152	26.0	41.8	135	168
17. Mullidae	1	1	2	101.0	50.5	180	49.1	51.9	180	180
(1) Mulloidichthys		1	2	101.0	50.5	180	49.1	51.9	180	180
M. martinicus			2	101.0	50.5	180	49.1	51.9	180	180
18. Chaetodontidae	1	2	5	116.5	48.0	94	0.8	95.3	38	150
(1) Chaetodon		2	5	116.5	48.0	94	0.8	95.3	38	150
C. capistratus			4	21.2	6.2	59	0.8	11.7	38	80
C. striatus			1	95.3			---			
19. Pomacentridae	4	8	102	1140.7	42.3	121	0.2	84.4	20	333
(1) Abudefduf		1	9	302.9	37.8	128	17.6	58.0	105	150
A. saxtilis			9	302.9	37.8	128	17.6	58.0	105	150
(2) Chromis		2	16	282.1	45.7	154	7.0	84.4	87	333
C. cyanea			11	172.8	16.4	162	10.2	22.5	103	333
C. multilineata			5	109.3	45.7	112	7.0	84.4	87	136
(3) Eupomacentrus		4	71	377.1	12.4	63	0.2	24.5	20	106
E. fuscus			43	329.3	12.4	72	0.2	24.5	37	106
E. leucostictus			4	13.0	5.3	54	0.6	10.0	39	70
E. variabilis			14	9.5	0.6	31	0.3	0.9	20	42
E. planifrons			10	25.3	2.6	52	0.6	4.7	35	69
(4) Microspathodon		1	6	178.6	33.6	106	4.6	62.6	65	147
M. chrysurus			6	178.6	33.6	106	4.6	6.6	65	147

TABLE 15 (Cont'd)

	#gen	#[illegible]	#[illegible]	T[illegible] [illegible]	M[illegible] [illegible]	M[illegible] [illegible]	RANGE WT. G. [illegible]		RANGE LGT. CM. [illegible]	
0. L[illegible]	2	3	9	17.2		55	T	3.6	29	81
(1) H[illegible]		2	4	6.7		38	T	2.5	29	48
H. [illegible]			3	6.7	2.3	46	2.1	2.5	43	48
I. [illegible]			1	T				---		
(2) Thalassoma		1	5	10.5	2.4	64	1.2	3.6	47	81
T. [illegible]			5	10.5	2.4	64	1.2	3.6	47	81
S[illegible]	3	7	69	422.8	23.4	87	0.5	46.3	35	139
(1) N[illegible]		1	1	10.8						
			1	10.8						
(2) Scarus		4	56	201.7	10.0	75	0.5	19.5	35	115
S. coeruleus			6	49.7	11.1	92	2.7	19.5	68	115
S. croicensis			35	85.6	4.4	62	0.5	8.4	35	89
S. taeniopterus			13	56.4	4.8	58	1.3	8.2	39	77
S. [illegible]			2	10.0	5.0	78	4.0	6.0	71	86
(3) Sparisoma		2	12	210.3	24.0	91	1.7	46.3	43	139
S. [illegible]			3	77.3	25.2	103	19.3	31.2	93	113
S. [illegible]			9	133.0	24.0	91	1.7	46.3	43	139
. A[illegible]	1	3	17	277.1		98	T	58.2	36	159
(1) A[illegible]		3	17	277.1	----	98	T	58.2	36	159
A. bahianus			9	221.2	31.3	118	4.4	58.2	77	159
A. chirurgus			4	45.4	14.8	92	5.6	23.9	65	120
A. coeruleus			4	10.5		83	T	4.7	36	130
3. Gobiidae	2	2	6	3.7	0.6	50	0.2	1.0	36	65
(1) (genus [illegible])		1	2	1.4	0.7	56	0.7	0.7	52	59
([illegible])			2	1.4	0.7	56	0.7	0.7	52	59

TABLE 15 (C[illegible]'[illegible])

	#gen	#sp	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	large	RANGE LGT. CH. small	large
(Continued)										
23. Gobiidae										
(2) Gnatnolepis		1	4	2.3	0.6	50	0.2	1.0	36	65
G. thompsoni			4	2.3	0.6	50	0.2	1.0	36	65
24. Dactyloscopidae	1	1	1	1.0						
(1) Gillellus		1	1	1.0						
G. uranidea			1	1.0						
25. Clinidae	1	2	4	10.0	3.1	83	1.5	4.7	54	112
(1) Labrisomus		2	4	10.0	3.1	83	1.5	4.7	54	112
L. guppyi			1	4.7						
L. haitiensis			3	5.3	1.8	56	1.5	2.2	54	57
2o. Brotulidae	3	3	5	11.3	4.4	63	0.2	8.5	33	93
(1) Brotula		1	1	0.2						
B. sp.			1	0.2						
(2) ~~Calamopterxx~~		1	3	2.6	0.8	58	0.6	1.0	52	63
C. goslinei			3	2.6	0.8	58	0.6	1.0	52	63
(3) Petrotyx		1	1	8.5						
P. sanguineus			1	8.5						
Atnerinidae	1	1	23	34.0	1.4	60	0.6	2.2	49	72
(1) Allanetta		1	23	34.0	1.4	60	0.6	2.2	49	72
A. harringtonensis			23	34.0	1.4	60	0.6	2.2	49	72
2o. balistidae	1	1	3	178.0	62.4	145	51.4	73.5	135	155
(1) Cantherines		1	3	178.0	62.4	145	51.4	73.5	135	155
C. pullus			3	178.0	62.4	145	51.4	73.5	135	155

TABLE 15 (Cont'd)

	#gen	#sp.	#spec	Total wt. g.	Mean wt. g.	Mean lgt.	RANGE WT. G. small	RANGE WT. G. large	RANGE LGT. CM. small	RANGE LGT. CM. large
29. Ostraciidae	1	1	1	25.2						
(1) Lactophrys		1	1	25.2						
L. triqueter			1	25.2						
30. T[illegible]	2	2	2	2.7			1.3	1.4	19	48
(1) Canthigaster		1	1	1.4						
C. rostrata			1	1.4						
(2) Sphaeroides		1	1	1.3						
S. testudineus			1	1.3						
SUMMARY	51	80	1213	35,568.25			Tr	718	19	725

TABLE 15 (Cont'd)

Winter December-February	Spring March-May	Summer June-August	Autumn September-November
(34 species)	(81)	(43)	(18)
Examples:			
Groupers	Snooks	Blue Marlin	Squirrelfishes
Bonefish	Jacks	Kingfish	Clinid blenny
Dolphin	Snappers	Mountain mullet	Gobies (Gobionellus)
Porgies	Cutlassfish	Cobia	Gerrids
Hogfish	White Marlin	Croakers	Trumpetfish
Triggerfish	Grunts	Gobies (Sicydium)	
Balaju	Tunas	Barracuda	
	Needlefish	Wahoo	

TABLE 16

DISTRIBUTION of 176 FISH SPECIES with SEASONAL SPAWNING PERIODS
(Erdman, 1968)

[illegible]	J	F	M	A	M	J	J	A	S	O	N	D
1. African [illegible]							[illegible]					
2. Almaco Jack												
3. Amberjack, greater												
4. Barracuda, great					f(m)		[illegible]					
5. Blue runner					[illegible]	([illegible])						
6. Bonefish	m											
7. Cobia												
8. Coney												
9. Cutlassfish			f	f								
10. Dolphin												
11. Grunt, bluestripped			f([illegible])									
12. Grunt, white			[illegible]									
13. Hind, red												
14. Hogfish												
15. Jack crevalle					m							
16 Jack bar												
17. Jack, horse-eye					m	(f)						
18. Mackerel, cero				m								
19. Mackerel, king							f	f				
20. Marlin, blue					m							
21. Marlin, white												
22. Mountain mullet												
23. Porgy, jolthead												
24. Snapper, blackfin												
25. Snapper, dog					[illegible]							
26. Snapper, gray												
27. Snapper, lane												
28. Snapper, mutton												
29. Snapper, schoolmaster						([illegible])		f				
30. Snapper, silk												
31. Snapper, vermilion												
32. Snook, swordspine												
33. Triggerfish, queen		f([illegible])										
34. Triggerfish, black durgon												
35. Tuna blackfin												
36. Tu-a, yellowfin						m						
37. Tuna, little												
38. Tuna, skipjack			[illegible]	([illegible])	[illegible]							
39. Yellowtail snapper			m		r				ı f			
40. Wahoo							m					
TOTAL	2	8	9	6	16	3		3		1	1	1

[illegible] males indicated by **m,** ripe females indicated by f.
Project data in parenthesis

TABLE 17

PEAK SEASONAL GONAD RIPENESS OF 40 SPECIES OF GAME FISH
([illegible], 1968)

TABLE NUMBER 18 Full Time Charter Boats in the American Virgin Islands

In Operation to Date:

Operation Terminated:

Age	Sample I		Sample II	
0-5	1	0	0	0
6-10	4	1	2	0
11-15	7	3	1	0
16-20	6	9	1	6
21-25	14	10	9	5
26-30	11	13	2	8
31-35	9	8	4	2
41-45	8	7	2	4
46-50	7	4	1	1
51-55	3	1	0	0
56-60	0	0	0	0
61-65	0	4	0	4
66-67	0	1	0	0
TOTAL	70	61	22	30

GRAND TOTAL = 183

You will of course note that the total of 183 out of 34,510 does not indicate a very high level of incidence. I should think there are a number of explanations of why this is so. The most important is the fact that we were not looking for "fish poisoning" and likely missed many cases. Many persons who have experienced the difficulty may not have sought assistance at the hospital and those who did may have been diagnosed in some other manner. With regard to this last hypothesis our researcher noted:

> "No lab. work appeared to investigate possible food poisoning. In the more recent records it could be noticed that the patient's self-diagnosis of fish poisoning appeared medically as 'Gastro-Enteritis'. The latter diagnosis also had frequent association with alcohol intake. The repeated admission of patients with Gastro-Enteritis after having alcoholic drinks leads to the suspicion that alcohol is a greater culprit than diagnoses reveal."

TABLE NUMBER 19 Incidents of Fish Poisoning from the Knud Hansen Memorial Hospital Records (Personal Communication from Hogsett, 1969)

Test No.	Crab weight (DO	Width (cm)	Injection sample	dose (cc/crab)	survival time (min.)
A	4.3	2.0	C	.2	48
B	5.3	2.0	C	.2	17
C	5.0	1.8	C	.2	63
D	3.5	1.6	C	.2	12
E	2.8	2.0	N	.2	–
F	4.5	2.1	N	.2	--
G	3.0	1.8	N	.2	--
H	5.0	2.0	S	.2	--
I	2.9	1.7	S	.2	--

<u>Legend</u>

C - No. 104 extract containing ciguatera toxin

N - Nova Scotia cod extract

S - Physiological saline

(cm) – Crab width is measured across the widest part of the carapace

– did not die within 48 hour observation period

TABLE 20

PRELIMINARY CIGUATERA TESTS ON <u>UCA PUGNAX</u>

Group no.	Dose (cc/crab)	Size (gm)	Size (cm)	No. Injected N.S.	No. Injected #104	No. survived* N. S.	No. survived* #104
A	.200	30.2	17.9	3	6	3	5
B	.100	29.3	18.1	3	6	2	5
C	.050	29.3	18.1	3	6	3	4
D	.025	29.5	17.9	3	6	2	5
E	.010	30.2	18.2	3	6	1	4

*Saline controls – Two crabs weighing between 2.8-3.3 gm. with 1.8-2.0 cm carapace widths were injected with each of the above dosage. None of the crabs receiving physiological saline died.

Legend:

Group no. Each group contained nine crabs
N.S. - Noval Scotia cod
#104 - Ciguatera containing fish tentatively identified as dog snapper
(gm) – total body weight in grams of nine crabs
(cm) – total width of nine crabs measured across the widest part of the carapace

TABLE 21

DOSE-RESPONSE CURVE FOR UCA PUGNAX

TISSUE	MOUSE (157) N	WP	MP	P	INC	MONGOOSE (48) N	WP	MP	P	INC	TOTALS
MUSCLE	30	41	10	--	3	23	4	5	6	4	128
LIVER	3	12	8	36	--	1	--	--	1	--	61
GONADS	1	1	2								6
VISCERA	--	--	1								4
WHOLE											8
TOTALS	34	54	21	45	3	28	4	5	7	4	205

N - Negative, no observable effects
WP - Weakly Positive-restlessness and unnatural behavior patterns
MP - Mildly positive - obvious.affected by adbominal cramps, diarrhea, hypo or hyper activity, ruffled hair.
P - Positive - paralysis, recumbency or death.
INC - Inconclusive
Numbers - Number of individual tests
% - WITHIN EACH TISSUE CATEGORY - except in totals where it represents percent of reaction category.

The same fish samples were used in both mouse and mongoose.

TABLE 22

COMPARISON OF MOUSE AND MONGOOSE AS BIO-ASSAY ANIMALS

APPENDIX B

TABLE 1

Birthplaces of commercial fishermen operating in the American Virgin Islands

Percentage of fishermen and island of operation

Birthplace	St. Thomas (33) 1/	St. Croix (32)	St. John (13)	Total (78)
U. S. V. I.:				
St. Thomas	42.5%			17.9%
St. Croix		53.2%		21.8
St. John		3.1	92.3%	16.6
Total US VI	[42.5]		[92.3]	[56.3]
Puerto Rico		15.7		6.4
U.S. Mainland		6.2	7.7	3.9
B. V. 2/				
Jost Van Dyke	6.1	-	-	2.6
Tortola	27.3		-	11.5
Virgin Gorda	3.0	-	-	1.3
Total BVI	[6.4]	-	-	[15.4]
Other Caribbean Islands:				
Anguilla	6.1	-	-	2.6
Antigua	-	3.1	-	1.3
Cuba	-	3.1	-	1.3
Dominica	3.0	-	-	1.3
Monserrat	-	3.1	-	1.3
Nevis	3.0	9.4	-	5.0
Saba	-	3.1	-	1.3
St. Barts	3.0	-	-	1.3
St. Kitts	3.0	-	-	1.3
St. Martin	3.0	-	-	1.3
Total other Caribbean islands	[21.1]	[21.8]	-	[18.0]
Total	100.0%	100.0%	100.0%	100.0%

1/ Number in parenthesis is the sample size.

2/ British Virgin Islands

TABLE 2

Personal and financial data for commercial fishermen landing catches in the American Virgin Islands

Location		Number of fishermen interviewed	Average age	Average number of dependents	Average number of years fished	Average capital invest- ment	Average annual operating expenses	Average net income
St. Thomas:	F[1/]	35	44.5	4. 1	26	$1220	$597	$3160
	-P	25	38.4	5. 1	15	796	234	1210
	Total	60	42.0	4. 5	21	1043	446	2348
St. Croix	-F	42	46. 8	4. 8	19	3490	614	3700
	-P	30	44.8	5. 7	16	1490	151	817
	Total	72	46.0	5.2	18	2657	421	2499
St. John	-F	6	55.0	0. 6	24	532	160	14 10
	-P	15	45.0	4. 6	17	1055	131	325
	Total	21	47. 9	3.5	19	906	139	635
Total USVI	-F	83	46.4	4.2	22	2319	574	3307
	-P	70	42.6	5.3	16	1149	176	852
	Total	153	44.7	4. 7	19	1784	392	2184
B. V. I.	-F	33	45.6	2.8	25	2942	797	1900[2/]
	-P	1	41.0	4. 0	10	754	390	546[2/]
	Total	34	45.5	2. 8	25	2878	785	1860[2/]

1/ F - full-time fishermen
P - part-time fishermen

2/ Only that earned for sales in the American Virgin Islands after deducting annual operating expenses.

TABLE 3

Power used on fishing craft landing seafood in the American Virgin Islands

Percentage used on:

Type of Power	St. Thomas (34) 1/	St. Croix (37)	St. John (16)	Total USVI (87)	BVI (13)
Oars	-	5.4	-	2.3	
Outboard gasoline engine	97.1(21) 2/	72.9(19)	93.7(8)	86.2(18)	38.4(18)
Inboard gasoline engine	2.9	8.2	-	4.6	
Inboard diesel engine	-	13.5	6.3	6.9	46.2
Sail plus diesel engine					
Total	100. 0%	100. 0%	100. 0%	100. 0%	100. 0%

1/ Number in parenthesis is the sample size.

2/ Number in parenthesis is the average horsepower.

TABLE 4

Capital investment of commercial fishermen landing catches in the American Virgin Islands

Capital investment:	St. Thomas (60) 1/	St. Croix (72)	St. John (21)	Total (153)	BVI (34) 2/
Boats& motors:					
number	36	37	16	89	13
average value	$1, 170	$4,550	$1,095	$2, 562	$6, 115
total value	$42, 114	$168 ,368	$17, 520	$228,002	$79, 490
Fish pots:					
number	340	443	55	838	408
average value	$32	$25	$21	$28	$23
total value	$10, 995	$1, 184	1, 160	$23, 339	$9, 396
Lobster pots:					
number	–	425		425	100
average value		$9		$9	$13
total	–	$3,770	–	$3,770	$1,300
Nets:					
feet	7, 090	5, 930	240	13, 260	5, 728
value	$9,500	$7,946	$336	17,782	$7,676
Total value	$62, 609	$191, 268	$19, 016	$272, 893	$97, 862
Average per fisherman	$1,043	$2,657	$906	$1,784	$2,878

1/ Number in parenthesis is the sample size.

2/ British Virgin Islands

TABLE 5

Gear used by commercial fishermen landing catches in the American Virgin Islands

Island of operation	Degree of effort	Number of fishermen interviewed	Pots y	Nets only	Lines only	Pots and nets	Pots and lines	Nets and lines	Pots, nets and lines
St. Thomas	full-time	35	18	–	–	2	9	–	6
	part-time	25	2	4	5	3	3	2	6
St. Croix	full-time	42	9	6	2	2	8	3	12
	part-time	30	19	–	4	–	5	2	–
St. John	full-time	6	2	2	2	–	–		
	part-time	15	8	–	–	–	7		
All USVI	full-time	83	29	8	4	4	17	3	18
	part-time	70	29	4	9	3	15	4	6
Total		153	58	12	13	7	32	7	24
B. V. I.[1/]	full-time	33	12			7			14
	part-time	1	1						
Total		34	13			7	–	–	14

1/ British Virgin Islands

TABLE 6

Gear and catch averages per Virgin Islands commercial fisherman

Location	No. of fishermen	No. of lines	Feet of net	No. of lobster pots	FISH POTS: No. of fish pots	FISH POTS: Fish pot life (months)	FISH POTS: Depth of set (fathoms	FISH POTS: Range in depth of set (fathoms)	FISH POTS: Average total pot hauls (week)	Average annual catch (lbs.) per man of: Fish	Lobster	Conch	Turtle
St. Thomas-F	35	0.43	108	0	8.1			–	20.9	9520	0	0	0
-P	25	0.56	132	0	2.3			–	5.0	2580	0	0	0
Total	60	0.48	118	0	5.7	14	11	5-30	14.3	6628	0	0	0
St. Croix -F	42	0.52	139	10.1	7.5			–	14.0 3/	4770	1387	248	1855
-P	30	0.30	3	0	4.3			–	5.7	2155	13	0	0
Total	72	0.43	82	5.9	6.2	13	15	5-30	10.5	3680	815	145	1082
St. John -F	6	0.33	40	0	1.7			–	5.0	2635	0	0	0
-P	15	0.47	0	0	3.0			–	5.1	1191	0	0	0
Total	21	0.43	11	0	2.6	21	13	6-24	5.1	1604	0	0	0
Total USVI-F	83	0.47	119	5.1	7.3			–	16.3	6619	702	125	939
-P	70	0.43	48	0	3.3			–	5.3	2100	6	0	0
Total	153	0.45	86	2.8	5.5	15	14	5-30	11.3	4551	384	68	509
B. V. I. -F	33	0.42	173	3.0	12.3			–	27.9 4/	7400	480	303	152
-P	1	0.00	0	0	3.0			–	3.0	1872	0	0	0
Total	34	0.41	168	2.9	12.0	15	40	5-250	27.2	7237	466	294	148

1/ Assumes only one line for each man that fishes hand-lines

2/ F - full-time
P - part-time

3/ Excludes 755 pot hauls per week for lobster.

4/ Excludes 100 pot hauls per week for lobster.

TABLE 7

Baits used by pot fishermen in the Virgin Islands

Number of fishermen using bait on:

Type of bait	St. Thomas (25)	St. Croix (26)	St. John (11)	BVI (9)	Total (71)
None	3	9	–	2	14
Sprat 2/	8	7		1	16
Dead fish	1	3	1	2	7
Fry 3/	6		–	–	6
Ballyhoo	2	2	–	–	4
Singed fish	3	–	–	–	3
Canned sardine	–	1	–	–	1
Spoiled meat	1	–	–	–	1
Conch	11	6	1	6	24
Sea urchin	4	–	6	2	12
Hermit crab	2		7	1	10
Whelk 4/	1	1	3	1	6
Lobster	4	–	–	–	4
Squid	–	1	–	–	1
Octopus	–	1	–	–	1
Sage bush 5/	4	3	4	1	12
Bread	8	1	–	–	9
Algae	–	7	1	1	9
Doctor grass 6/	–	1	3	3	7
Papaya	–	–	3	–	3
Cactus	–	–	1	1	2
Soursop 7/	–	–	1	–	1
Rotten oranges	–	–	1	–	1

1/ Number in parenthesis is the sample size

2/ Fishes of the genus Harengula

3/ Fishes of the genus **Anchoa** and family Atherinidae

4/ West Indian Topshell, Cittarium pica

5/ Lantana spp.

6/ Red Algae, Gelatinus: Gelidiales or Cryptonemiales ?

7/ Annona **muricata**

TABLE 8

Fisherman-reported variations in catch and monetary return in the Virgin Islands commercial fishery

	Fishermen response (frequency) for:				
Catch per unit effort has:	St. Thomas (21) 1/	St. Croix (18)	St. John (19)	BVI (23)	Total
Increased	3	6	1	1	11
Remained the same	12	13	4	3	32
Decreased	11	11	8	4	34
Monetary return for catch has:					
Increased	17	21	9	6	53
Remained the same	6	5	1	0	12
Decreased	1	2	2	1	6

1/ Number in parenthesis is the average number of years fished.

TABLE 9

Fisherman-reported problems in the Virgin Islands commercial fishery

Problem	St. Thomas	St. Croix	St. John	B. V. I.	Total
Loss of gear 1/	17	8	5	2	32
Weather	9	9	3	2	23
Theft of gear	6	10	3	0	19
Theft of fish	0	7	2	0	9
Engine trouble	5	2	0	1	8
Marketing	1	1	2	3	7
Spoilage	2	1	1	0	4
Pollution	0	1	0	0	1
Poor fishing	0	1	0	0	1
Cost of equipment	0	1	0	0	1
None	1	2	2	0	5

1/ Due primarily to boats cutting buoy lines.

TABLE 10

Government services or regulations requested by American Virgin Islands commercial fishermen

Government service or regulation	Percentage requesting the service or regulation on: 1/ St. Thomas (31)	St. Croix (38)	St. John (9)	Total (78)
1. Provide low interest loans for a year	12.9	23.7	11.1	17.9
2. Provide a marketing facility	29.0	7.9		15.4
3. A government outlet for gear purchases at wholesale prices	12.9	7.9	-	9.0
4. Alter navigation routes of Hess & Harvey ships from fishing grounds	-	13.2	-	6.4
5. Pollution abatement		10.5		5.1
6. Open National Park beaches to seining to high water mark	3.2		33.3	5.1
7. Provide a pier at existing market		5.3		2.6
8. Open private beaches to seining to high water mark	6.5			2.6
9. Provide paid officers for enforcement of existing fishing regulations	3.2	2.6	-	2.6
10. Regulate mesh size of pots to allow escapement of small fish		2.6		1.3
11. Prevent aliens from fishing	3.2			1.3
12. None	19.4	21.0	44.5	23.0
13. No opinion	9.7	5.3	11.1	7.7
Total	100.0%	100.0%	100.0%	100.0%

1/ Number in parenthesis is the sample size.

TABLE 11

Customer preference for local finfish, as reported by commercial fishermen landing catches in the American Virgin Islands

Species of fish		Percentage of fishermen listing fish among the bestsellers on:				
Common name	Scientific name	St. Thomas	St. Croix	St. John	BVI 1/	Total
Blue runner	Caranx crysos	18.0		19.0	10.0	12.2
Grouper	Serranidae	14.0	11.8	4.8	20.0	12.2
Yellowtail snapper	Ocyurus chrysurus	12.0	2.9	19.0		9.6
Snapper 2/	Lutjanus spp.	6.0	14.8	4.8		7.8
Bar jack	Caranx ruber	8.0		9.5		5.2
Surgeonfish	A canthurus spp.		11.8	4.8	10.0	5.2
Queen trigger fish	Balistes vetula	4.0	2.9	9.5		4.3
Parrotfish	Scaridae	–	14.8	–	–	4.3
Grunt	Haemulon spp.	4.0	2.9	–	20.0	4.3
Jack	Caranx spp.	4.0	5.9	–	–	3.5
Angelfish	Chaetodontidae	2.0	–	9.5	10.0	3.5
Margate	Anisotremus spp.	6.0	–	–	10.0	3.5
Hind	Epinephelus spp. 3/	4.0	–	–	10.0	2.6
Kingfish	Scomberomorus cavalla	4.0	–	–	–	1.7
Porgies	Calamus spp. 4/	2.0	–	4.8	–	1.7
Crevalle jack	Cara= hippos	–	5.9	–	–	1.7
Goatfish	Mullidae y	-	5.9	–	–	1.7
Red snapper	Lutianus spp. 6/	–	2.9	–	10.0	1.7
Dolphin	Coryphaena hippurus	–	2.9	–	–	0.9
Squirrelfish	Holocentrus spp.	–	2.9	–	–	0.9
Barracuda	Sphyraena barracuda	–	2.9	–	–	0.9
No preference, all sell well		12.0	8.8	14.3		10.6
Total		100.0%	100.0%	100.0%	100.0%	100.0%

1/ For fish sold in St. Thomas

2/ Excluding red snapper

3/ adscensionis and guttatus

arctifrons, bajonado, calamus and pennatula

5/ Mulloidichthys martinicus and Pseudupeneus maculatus

6/ buccanella and vivanus

TABLE 12

Commonly ciguatoxic **fish,** as reported by Virgin Islands commercial fishermen

Common name	Scientific name	St. Thomas (28) 1/	St. Croix (29)	St. John (13)	BVI (9)	Total (79)
Barracuda	Sphyraena barracuda	18	22	11	4	55
Amberjack	Seriola dumerili	8	13	7	2	30
Horse-eye jack	Caranx latus	9	7	6	3	25
Bar jack	Caranx ruber	11	1	7		19
Crevalle jack	Caranx hippos	4	6	3	2	15
Dog snapper	Lutjanus jocu	11		2	2	15
Yellowfin grouper	Mycteroperca venenosa	6	2		1	9
Kingfish	Scomberomorus cavalla	4	1		1	6
Blue runner	Caranx crysos		5			5
Conger	Conger spp.	3	2			5
Rock hind	Epinephelus adscensionis	4				4
Black grouper	Mycteropca bonaci	2			2	4
Cero	Scomberomorus regalis	3				3
Sardine	Harengula		3			3
Black jack	Caranx lugubris	1			1	2
Hogfish	Lachnolaimus maximus	1			1	2
Gray snapper	Lut anus griseus	2				2
Almaco jack	Seriola falcata			1		1
Yellow jack	Caranx bartholomaei		1			1
Red hind	Epinephelus guttatus			1		1
Black snapper	Apsilus dentatus	1				1
Blackfin snapper	Lutjanus buccanella				1	1
Queen trigger fish	Balistes vetula	1				1
Tarpon	Megalops atlanticus	1				1
All fish, occasionally		3	1			4
No fish			1		1	2

1/ Number in parenthesis is the sample size.

TABLE 13

Areas often yielding ciguatoxic **fish,** as reported by Virgin Islands commercial fishermen

Location	Frequency reported	Total
St. Croix:		4
East End	1	
Lang Bank	1	
South side	1	
White Horse		
St. John:		15
Congo Cay	1	
East End	1	
Reef Bay	3	
South side	8	
White Point	2	
St. Thomas:		14
Buck Island	4	
French Cap Cay	3	
North side	1	
South side	6	
British Virgin Islands:		16
Anegada Reef near Roccos	3	
East End, Tortola	1	
Necker Island	2	
Necker Island Pass	1	
Peter Island	3	
Saba Rock	2	
Saba Island, N. W. I.	1	1
Any Area	34	34
Grand Total		84

TABLE 14

Methods used by commercial fishermen to recognize ciguatoxic or non-ciguatoxic fish

Method	Frequency reported
1. Ciguatoxic fish have different coloration than normal fish:	
a. More yellow or brassy	3
b. Stripes	2
c. Darker	2
2. Presence of isopod parasite indicates non-ciguatoxic fish.	3
3. Raw flesh of ciguatoxic fish, especially the liver, tastes bitter or hot in mouth.	3
4. Flies will not land on exposed flesh of ciguatoxic fish.	3
5. Silver turns black when boiled with ciguatoxic fish.	3
6. Sweet potato turns black when boiled with ciguatoxic fish.	2
7. Ciguatoxic fish have brassy or coppery odor.	2
8. Ciguatoxic fish have enlarged or bloated stomach.	1
9. Ciguatoxic fish have yellow mucous on inner lining of gullet.	1
10. Ciguatoxic fish have green tint to raw flesh.	1
11. Suspected specimen with roe is ciguatoxic.	1
12. Ants will not eat ciguatoxic fish.	1
13. Ciguatoxic fish have tiny black "veins" running through the flesh.	1
14. None.	59

TABLE 15

Prices paid for seafood products in the American Virgin Islands during 1967-68 (used in computing seafood value in subsequent tables)

Fish	Average price per lb. 1/	Price range	Shellfish	Average price per lb. 1/	Price range
Cod	$0.53	-	Clams	$0.88	$0. 57-1.19
Dolphin	0.55	$0.45-0.65	Crab	2.08	1. 95 -2.19
Flounder	0.88	0.54-0.99	Conch	0.59	0.35-0.65
Grouper	0.55	0.40-0.59	Lobster-tails	2.65	2.37-3.15
Halibut	0.99	0. 99-1. 08	Lobster	0.85	0.69-0.99
Jack 2/	0.35	0. 18-0. 50	Octopus	0.69	
Kingfish	0.59	0. 34-0.65	Oysters	2. 10	
Misc. fish 3/	0.60	0. 18-1. 08	Scallops	1.18	1. 09-1. 39
Pot fish 4/	0.50	0. 40-0. 55	Shrimp	2.10	-
Salmon	1.03	1. 03-1. 25	Squid	0.43	-
Salt fish	0.48	0.40-0. 60	Turtle	0.75	
Sea bass	0.60	-	Whelk 5/	0.40	
Sea perch	0.60	-			
Snapper	0.60	0.48-0.65			
Sole	0.88	0. 54-0. 98			
Swordfish	0. 95	0. 90-0. 98			
Trout	1.05	0. 93-1.20			
Turbot	0.75	-			
Wahoo	0.45	0.40-0. 65			

1/ Includes both retail and wholesale prices; for many items, the wholesaler is sole supplier.

2/ Primarily blue runner, bar jack and bluntnose jack.

3/ Includes all fish that could not be separated into categories; both whole fish and fillets.

4/ Reef fishes: primarily parrot fishes, surgeon fishes, trigger fishes, grunts, squirrel fishes, snappers, groupers, etc.

5/ West Indian Topshell.

TABLE 16

Annual local seafood landings in the American Virgin Islands (1967-68)

Product	Landings by American Virgin Islands fishermen 1/		Landings by British Virgin Islands fishermen 1/		Total	Total
	Pounds	Value	Pounds	Value	pounds	value
Fish	1,382,400	$691,200	290,000	$145,000	1,672,400	$836,200
Lobster	85,900	73,015	18,640	15,844	104,540	88,859
Conch	15,100	8,909	11,760	6,938	26,860	15,847
Whelk 2/	-	-	-	-	22,305	8,922
Turtle	11,280	8,460	5,880	4,410	17,160	12,870
Squid	390	168			390	168
Octopus	208	144	-	-	208	144
Total	1,495,278	$781,896	326,280	$172,192	1,843,863	$963,010

1/ Excluding whelks; see note 2 below.

2/ Whelks (West Indian Topshell) are normally harvested from shore and the landings of this item were not detected in the survey of fishermen. Whelk figures were obtained from the commercial outlet survey, and are included in "total pounds" and "total value" only.

TABLE 17

Local seafood products used annually by commercial outlets in the American Virgin Islands (1967-68)

Product	St. Thomas Weight	St. Thomas Value	St. Croix Weight	St. Croix Value	St. John Weight	St. John Value	Total Weight	Total Value
Fish	141,900	$70,950	57,534	$28,767	73,060	$36,530	272,494	$136,247
Lobster	62,960	53,516	33,280	28,288	780	663	97,020	82,467
Conch	6,300	3,717	11,960	7,057	1,560	920	19,820	11,694
Whelk 2/	21,265	8,506	520	208	520	208	22,305	8,922
Turtle	600	450	–	–	–	–	600	450
Squid	–	–	390	168	–	–	390	168
Octopus	–	–	208	144	–	–	208	144
Total	233,025	$137,139	103,892	$64,632	75,920	$38,321	412,837	$240,092

1/ Includes only a single grocery on each St. Thomas and St. Croix; all other data *were* from eating establishments.

2/ West Indian Topshell.

TABLE 18

Annual use by St. Thomas commercial outlets of seafood products imported from Puerto Rico and the U. S. mainland (1967-68)

Item	Wholesale groc. weight (lbs.)	Retail groc. weight (lbs.)	Restaurants weight (lbs.)	Total weight (lbs.	Total value 2/
Fish 3/	92,370	145,280	33,630	271,280	$162,768
Salt fish	84,000			84,000	40,320
Kingfish	52,120			52,120	30,751
Jack 4/	33,200			33,200	11,620
Snapper	3,600			3,600	2,160
Grouper	3,120			3,120	1,716
Sole	3,000			3,000	2,640
Swordfish	1,080			1, 080	1,026
Total	272,490	145,280	33,630	451,400	$253,001
Shrimp	80,390	7,000	8,300	95,690	$200,949
Lobster-tail	33,380	1,480	4,420	39,280	104,092
Lobster	8,490			8,490	7,217
Crab	32,920		3,960	36,880	76,710
Scallops	1,840		2,190	4,030	4,755
Oysters	1, 500			1,500	3,150
Clams			185	185	163
Total	158,520	8,480	19,055	186,055	$397,036
Grand Total	431,010	153,760	52,685	637,455	$650,037

1/ Only those importing directly from Puerto Rico and the U. S. mainland.

2/ Current average value.

3/ Steaks, fillets and whole fish of: kingfish, jack, snapper, grouper, sole, swordfish, trout and flounder.

4/ Primarily blue runner, bar jack, bluntnose jack.

TABLE 19

Annual use by St. Croix commercial outlets of seafood products imported from Puerto Rico and the U. S. mainland (1967-68)

Item	Wholesale groc. weight (lbs.)	Retail groc. 1/ weight (lbs.)	Restaurants 1/ weight (lbs.)	Total weight (lbs.)	Total value 2/
Kingfish	47,520	192,000		239,520	$141,317
Misc. fish 3/	20,160	19,800	15,080	55,040	27,520
Grouper	6,640	48,000		54,640	30,052
Jack 4/	30,000	18,000		48,000	16,800
Snapper	1,000	18,000	2,080	21,080	12,648
Salt fish		18,000		18,000	8,640
Sole	12,840		3, 640	16,480	14,502
Flounder	7,200			7,200	6,336
Halibut	4,680			4,680	4,633
Swordfish	3,000		650	3,650	3,468
Trout	1,920		780	2,700	2,835
Salmon		770	840	1,610	1,658
Sea perch	840			840	504
Sea bass			780	780	468
Turbot			520	520	390
Total	135, 800	314,570	24,370	474,740	$271, 771
Shrimp	52,200	18,000	9,390	79,590	$167,139
Lobster-tail	10,800	10,080	11,270	32,150	85,198
Crab	16,200	3,170	2,460	21,830	45,406
Scallops	7,800	2,300	2,400	12,500	14,750
Squid		4,800		4,800	2,064
Conch			7,000	7,000	4,130
Octopus		2,400		2,400	1,656
Clams		1,920		1,920	1,690
Total	87,000	42,670	32,520	162,190	$322,033
Grand Total	222,800	357,240	56,890	636,930	$593,804

1/ Only those importing directly from Puerto Rico and the U. S. mainland.

2/ Current average value.

3/ Steaks, fillets and whole fish of: kingfish, jack, grouper, snapper, sole, swordfish, etc.

4/ Primarily blue runner, bar jack and bluntnose jack.

TABLE 20

Foreign seafood imported into the American Virgin Islands during 1967 1/.

Country	Shellfish Pounds	Shellfish Value	Fish Salted & Smoked Pounds	Fish Salted & Smoked Value	Fish Frozen Pounds	Fish Frozen Value	Total Pounds	Total Value
Australia	390	$1,064					390	$1,064
Bahamas	150	336					150	336
British Honduras	680	1,462					680	1,462
British West Indies	3,999	1,350					3,999	1,350
Canada	500	330	33,630	$13,887	3,920	$1,743	38,050	15,960
Chile	4, 866	6,142					4,866	6,142
Costa Rica	800	1,504					800	1,504
Denmark	450	360			1,290	640	1,740	1,000
Ecuador	750	1,157					750	1,157
France	2,569	2, 980					2,569	2,980
French Guiana	4, 984	8,253					4,984	8,253
Greenland	312	733			477	613	789	1,346
Guyana	250	310					250	310
Haiti	1,204	2, 032					1,204	2,032
Japan					500	305	500	305
Mexico	1,905	2,639			3,000	1,445	4,905	4,084
Netherlands			49,590	17,145			49,590	17,145
Nicaragua	1,500	1,836					1,500	1,836
Norway			392,426	119,101			392,426	119,101
Pakistan	1,000	1,275			1,000	515	2,000	1,790
Panama	200	290					200	290
Peru	1,260	1,512					1,260	1,512
Taiwan	300	972					300	972
Venezuela	300	399					300	399
Total	28,369	$36,936	475,646	$150,133	10,187	$5,261	514,202	$192,330

1/ Data derived from compilation of monthly tally sheets of "Foreign Trade Report No. IM 141 - V" (U.S. Department of Commerce, Bureau of the Census).

TABLE 21

Foreign shellfish imported into the American Virgin Islands during 1967

	Lobster		Shrimp		Scallops		Snails		Total	
Country	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Australia	390	$1,064							390	$1,064
Bahamas	150	336							150	336
British Honduras	680	1,462							680	1,462
British West Indies	3,999	1,350							3,999	1,350
Canada					500	$330			500	330
Chile	4,866	6,142							4,866	6,142
Costa Rica	800	1,504							800	1, 504
Denmark					450	360			450	360
Ecuador			750	$ 1, 157					750	1, 157
France							2,569	$2,980	2,569	2,980
French Guiana	1, 090	2,646	3,894	5,607					4,984	8,253
Greenland			312	733					312	733
Guyana			250	310					250	310
Haiti	1,204	2,032							1,204	2,032
Mexico	540	965	1,365	1, 674					1, 905	2, 639
Nicaragua			1,500	1,836					1,500	1,836
Pakistan			1, 000	1, 275					1, 000	1,275
Panama			200	290					200	290
Peru	1,260	1,512							1,260	1,512
Taiwan	300	972							300	972
Venezuela			300	399					300	399
Total	15,279	$19,985	9,571	$13,281	950	$690	2,569	$2,980	28,369	$36,936

TABLE 22

Foreign salted and smoked fish imported into the American Virgin Islands during 1967

Country	Salt Cod		Salt Mackerel		Other Salt Fish		Smoked Herring		Total	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Canada	33,630	$13,887							33,630	$13,887
Netherlands	47,575	16,834	2,015	$311					49,590	17, 145
Norway	197,722	69,078	14,830	3,525	174,582	$45,660	5,292	$838	392,426	119, 101
Total	278,927	$99,799	16, 845	$3,836	174,582	$45,660	5,292	$838	475,646	$150, 133

TABLE 23

Foreign frozen fish imported into the American Virgin Islands during' 1967

	Haddock		Swordfish		Cod		Other fish		Total	
Country	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Canada	1,520	$718			600	$276	1,800	$749	3,920	$1,743
Denmark							1,290	640	1, 290	640
Greenland							477	613	477	613
Japan			500	$ 305					500	305
Mexico							3,000	1,445	3,000	1,445
Pakistan							1, 000	515	1, 000	515
Total	1,520	$718	500	$305	600	$276	7,567	$3,962	10,187	$5,261

TABLE 24

Preservation of fish purchased by commercial outlets in the American Virgin Islands

Outlet and location	Total Number	Number purchasing fish that were: Not processed: Not Iced	Iced	Frozen	Processed: Not Iced	Iced	Frozen 1/
Restaurants –							
St. Thomas	55	18	1	2	8	-	27
St. Croix	29	7	-	-	7	-	19
St. John	6	5	-	-	1		3
Total Restaurants	[90]	[30]	[1]	[2]	[16]		[49]
Groceries –							
St. Thomas	17	1	-	-	-	-	16
St. Croix	8			-		-	7
St. John	1	-	-	-	-	-	1
Total Groceries	[26]	[2]					[24]
Total Outlets	116	32	1	2	16		73

1/ Two outlets on St. Thomas, and one on St. Croix, handled local frozen fish. Other frozen fish was imported from Puerto Rico and the U. S. mainland.

TABLE 25

Restaurant[1] **willingness** to pay higher prices for local fish, if product has been processed and priced

Location	Number of restaurants	Willing	Not willing	No opinion
St. Thomas	55	39	13	3
St. Croix	29	18	7	4
St. John	6	5	1	
Total	90	62	21	7

1/ Including restaurants using only non-local frozen fish.

2/ Gutted, scaled or filleted; occasionally, portion-control cuts.

TABLE 26

Requirements for additional local seafood, as indicated by commercial outlets using seafood in the American Virgin Islands

Location	GROCERIES					RESTAURANTS				
	Wholesale		Retail			Using primarily non-local seafood		Using primarily local seafood		
	Number inter-viewed	Percentage requiring additional seafood	Number inter-viewed	Percentage requiring additional seafood	Total 1/ inter-viewed	Number inter-viewed	3/ Percentage requiring additional seafood	Number inter-viewed	2/ Percentage requiring additional seafood	Total inter-viewed
St. Thomas	7	57.2	10	60. 0	17	27	74.0	28	75. 0	55
St. Croix	4	75. 0	4	50. 0	8	19	89.5	10	60. 0	29
St. John			1	100. 0	1			6	83. 3	6
Total	11	63.5	15	60.0	26 4/	46	80.5	44	72.8	90

1/ Includes all groceries handling seafood products.

2/ More than 90% of the restaurants using seafood.

3/ Includes all restaurants importing seafood directly.

4/ Includes several chains with more than one outlet.

TABLE 27

Order of preference for local seafood, as listed by commercial outlets in the American Virgin Islands

Local seafood product	St. Thomas restaurants utilizing primarily Non-local seafood 1/	St. Thomas restaurants utilizing primarily Local seafood	St. Croix restaurants utilizing primarily Non-local seafood 1/	St. Croix restaurants utilizing primarily Local seafood	St. John restaurants utilizing primarily Non-local seafood 1/	St. John restaurants utilizing primarily Local seafood	St. Thomas wholesale & retail groceries	St. Croix wholesale & retail groceries	St. John wholesale & retail groceries
Red snapper	1	8	1	1		3	2	1	
Grouper	2	3	2			4	1	4	
Lobster	3	6	3			1	4	2	
Kingfish	5	2	4	2		5	3	3	1
Yellowtail snapper	6	7		3		7			
Pot fish 2/	4	1	6	4			7		3
Conch	7	4				2	5		
Whelk 3/	8	5				6	6		
Dolphin	9	9	5						
Jack 4/	10						8		2
Barracuda				6					
Tuna			7						
Hind							9		
Turtle 5/		10		5					

1/ Chiefly seafood imported from Puerto Rico and the U. S. mainland.

2/ Includes parrot fishes, trigger fishes, small snappers and groupers, squirrel fishes, trunk fishes, surgeon fishes, angel fishes and other reef fishes.

3/ West Indian Topshell.

Includes blue runner, bar jack and bluntnose jack.

5/ Primarily green and hawksbill.

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