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A STUDY OF LAGOONAL AND ESTUARINE PROCESSES AND ARTIFICIAL HABITATS IN THE AREA OF THE JOHN F. KENNEDY SPACE CENTER

By
Premsukh Poonai

ORIGINAL CONTAINS COLOR ILLUSTRATIONS

A first annual report on a project conducted by Bethune-Cookman College under a financial grant made by the National Aeronautics and Space Administration
September 1972 - October 1973

TABLE OF CONTENTS

ABSTRACT

In order to study the influence of an artificial habitat of discarded automobile tires upon the biomass in and around it, three sites were selected in the Banana River, one of which will serve as a control and the other two as locations for small tire reefs. One of the reefs has been established and the other is on the point of being laid down. Measurements and correlation studies of the biomasses and the species indicate that the Biodynamics of the sites are appreciably the same in the three cases, that there are probably adequate populations at the lower trophic levels, that there are perhaps reduced numbers of upper level carnivores and that it is likely that small artificial havens can contribute to an increase in populations of certain species of gamefish.

INTRODUCTION

Aims

The purpose of the project during the period September 1, 1972 to October 31, 1973 was to study the Biodynamics of the Banana River in the neighborhood of the John F. Kennedy Space Center, to determine if the game-fish population of the area can be increased by the use of artificial habitats and to initiate the students of Bethune-Cookman College into the methods of Biological Research in the Field.

Review of literature

In the 1970 report of the overall Economic Development Committee of Brevard County of the State of Florida, Verlander (23) has recorded the views of the Task Forces of the Committee emphasizing the need for improving the lagoonal and estuarine resources. Among the steps recommended by the Committee are expansion of sport fishing and tourism, establishment of hatcheries, use of aquacultural techniques and a comprehensive environmental management study for predicting the effect of growth upon the environment.

The Committee considers that lagoonal and estuarine resources can contribute about 50 million dollars per annum to the gross income of the County instead of two million dollars as at the present time. However, there is no evidence of yearly growth in fish production at this time.

Lack of growth in the fish industry is a matter for some concern since a National Estuary Study (11) has indicated that the human population is increasing in the estuarine areas at a far higher rate than in the nation as a whole and that about 2/3 of the United States commercial fish supply can be attributed to estuarine dependent species.

Investigations carried out by a number of workers indicate a decline in fish production in recent years. Mr. Robert M. Ingle (10) formerly Chief of the Bureau of Marine Science and Technology of the State of Florida has stated that the estuaries of Florida and in fact most of the coastal waters of the United States have lost their productivity rapidly due to littoral development and pollution. Futch (7) has recorded a decline in commercial landings of the spotted seatrout for the East Coast of Florida. Tabb (20) working for the Marine Laboratory of the University of Miami reported a decline in commercial landings for Florida as a whole during the period 1949 to 1958. Tabb (21) also observed a similar trend in the Indian River in Brevard County.

Resulting from an investigation ordered by the Florida State Board of Conservation, Hutton et al (9) reported that reduction of stands of turtle grass, *Thalassia testudinum* and cord grass, *Spartina patens* is harmful to associated animal life which utilize the site as feeding and breeding grounds. Philips (14) and Odum et al (13) also stressed the importance of marine grasses such as *Zostera marina* and *Thalassia testudinum* and associated algae for primary productivity. Such communities are known to occur in the Indian River and St. Lucie Inlet. The importance of adequate quantities of decomposed organic matter for primary productivity has been studied extensively by Finenko and Zaika (5). They have established a close relationship between annual primary production and detritus level. It hardly needs to be mentioned that it may be expected that the productivity of the estuarine environment under study would also be influenced by the phytoplankton biomass as Raymont (16) has discussed exhaustively.

Personnel

Lists of personnel who are actively engaged in the program and who serve in an advisory capacity are given in Appendices 1 and 2.

MATERIALS AND METHODS

Use of artificial habitats

In view of the results obtained with fish havens in marine habitats (1), (2), (3), (19), (22), it was decided to study the possibility of ameliorating an estuarine environment by the use of artificial havens. This is being done by considering the biomasses at each trophic level before and after haven establishment. Comparison of the biomasses of the various trophic levels before haven establishment would indicate whether it is possible to maintain larger populations at the highest level on the basis of food supplied by the lower levels. After haven establishment, measurements will continue in order to observe if biomasses have altered around them.

Experimental sites

Three experimental sites have been chosen for the project and they are shown in Fig. 1. Site A is about 75 meters South of Bennett Causeway off Kelly's Park. Site B is about 75 meters North of NASA Causeway and East of the Bridge which lies across the Banana River. Site C is an area about one hectare in extent in the Banana River adjacent to the Kennedy Area Recreation Center.

Details of the artificial habitats

An artificial haven or reef consisting of about 50 tires has been placed at Site A in accordance with the plan shown in Fig. 2. A reef of the same size is about to be placed on the location shown in Fig. 3.

The tires are weighted down with blocks of concrete, pierced for the occluded air to escape and bound with wire into configurations of three-tire units as shown in Fig. 4. They are then transported to the site by means of a small barge as shown in Fig. 4 placed on the estuarine bed and held together by a common cord.

Number of field visits

The biomasses at the various trophic levels at the three sites were measured on 15 occasions at Site A, Kelly's Park, ten at Site B, NASA Causeway and ten at Site C, the Kennedy Area Recreation Center.

Interpretation of field data

The biomass data have been used for comparing the three sites and for determining whether the artificial havens may be expected to increase the size of the populations of gamefish. Comparison of the sites was carried out by finding the degree of correlation between the numbers of the various species which were found at each site and by a direct comparison of the biomasses at each trophic level. It was possible to decide whether the estuary can maintain a larger gamefish population than it contains at the present time, by comparing the biomass of the uppermost trophic level with those at the lower levels.

The values which were used for estimating correlations between frequencies of the observed species at the three sites are given in Tables 1 and 2. A significant positive correlation would indicate that the relative numbers of the various species tend to be more or less the same on the three sites, that is to say, it would mean that the Biodynamics of the estuary are reasonably uniform in the area of the John F. Kennedy Space Center. The type of correlation coefficient employed for the data of Tables 1 and 2 was Spearman's Rank Correlation Coefficient (24). The significance of the coefficient was determined by the use of tables published by Oliver and Boyd (6).

Classification of organisms into trophic levels

For the purpose of expressing biomass at the various trophic levels, the organisms were classified as shown on Table 3. The actual biomasses under the categories shown in Table 3 are given in Tables 4, 5 and 6. The values for Site A have been arranged in a partial energy flow diagram in Fig. 5. The biomass values for the other two sites have not been similarly arranged because they show basically the same trend and lead to the same conclusions.

Sampling methods

In order to make estimates of the biomass at various levels, several methods were employed.

Plankton samples were collected weekly from the top 3' of the site by filtering one cubic meter of water through a plankton net having 2500 holes per cm^2. The micro-debris was estimated in mixture with the phytoplankton and converted into calories per gram by the same multiplying factor. All weights were expressed in mg/m^3 dry weight.

Grasses, algae and bottom animals were sampled by using a bottom-sampling dredge which lifts a soil sample 4" deep. About 1/5 m^2 of soil is collected on each sampling date, and washed through a sieve having 64 holes per cm^2. The animals and plant material are separated dried and expressed as gm/m^2, dry weight.

Small fish and shrimps were sampled by drawing a seine 20' long by 6' wide having ¼ mesh over a distance of 50' on each occasion on Sites A, B and C. The biomass is expressed as gms/m^2, dry weight. This group of organisms provides food for larger fish and crabs.

Large fish of edible size could not be trapped in any appreciable quantities by a cast-net or a 14' wide try-net. Also, anglers have made disappointing catches over considerable periods of time on a large number of locations each day so that it is not reliable to use their catches to represent the yield of edible fish. A 100' seine having 1" mesh has proven to be the best method of estimating the yield of large fish and crabs.

Energy flow model

The energy relationships between the trophic levels may be represented partially as shown in Fig. 5 in which the symbols have the following meanings (12): -

X_1, X_2, X_3, X_4 = cal./m^2/year as initial biomass

F_{01} = Kcal./m^2/year incident energy

F_{10}, F_{20}, F_{30} = cal. respired/m^2/year

F'_{10} = cal/m^2/year lost downstream

F'_{30} = cal/m^2/year harvested

F_{14}, F_{24}, F_{34} = cal/m^2/year lost by death

t = feeding rate

r = respiration rate

m = mortality rate

h = rate of harvesting

l = rate of loss downstream

One of the purposes of the present project is to generate data in accordance with the model shown in Fig. 5 in an attempt to investigate the Biodynamics of the estuary in the neighborhood of the John F. Kennedy Space Center.

Figure 1

MERRITT ISLAND NATIONAL WILDLIFE REFUGE

BREVARD COUNTY, FLORIDA

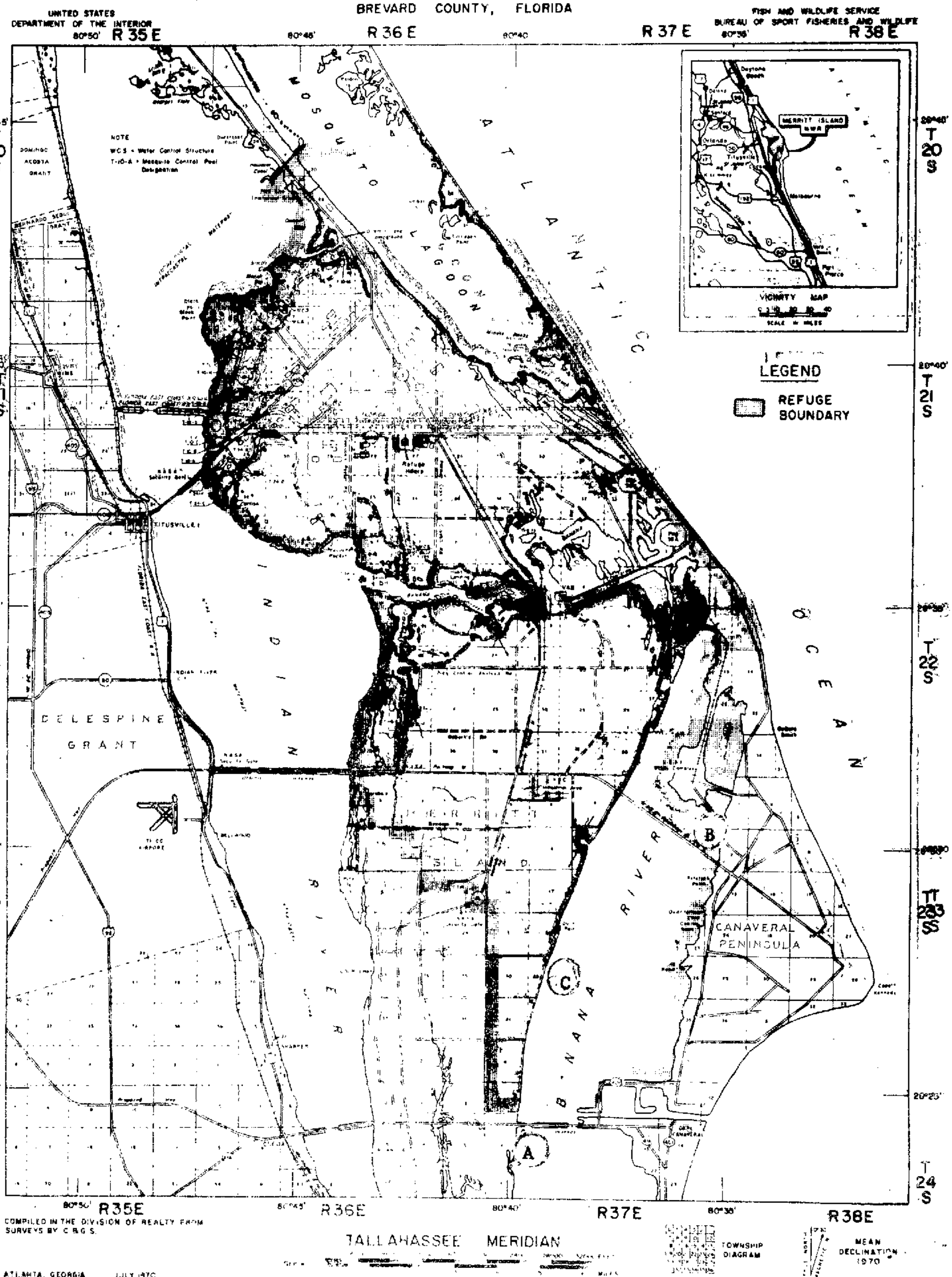
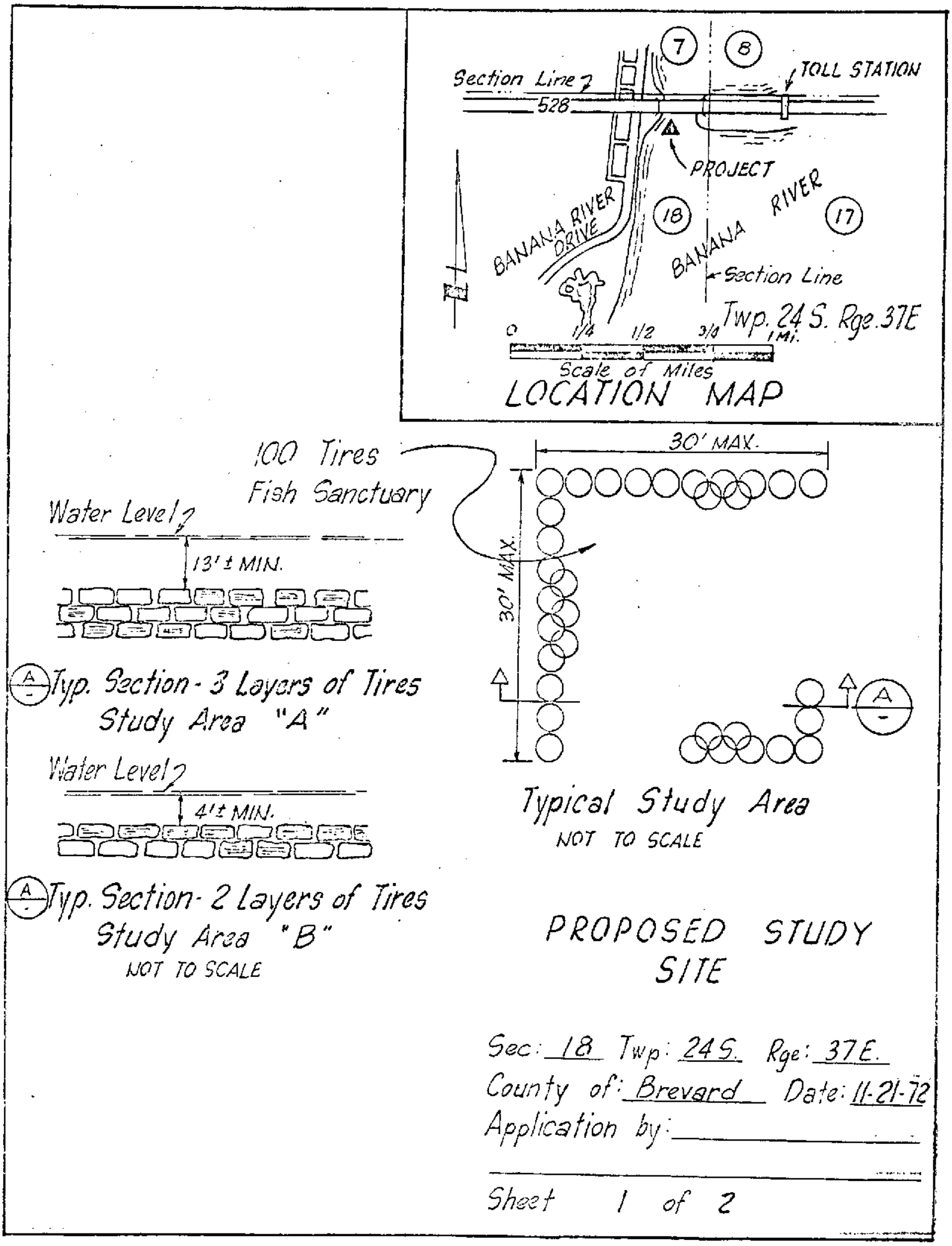


Figure 2



Section Line
528
7
8
TOLL STATION
PROJECT
BANANA RIVER DRIVE
18
BANANA RIVER
17
Section Line
Twp. 24 S. Rge. 37E
0 1/4 1/2 3/4 1 Mi.
Scale of Miles
LOCATION MAP
100 Tires Fish Sanctuary
30' MAX.
30' MAX.
Water Level
13' ± MIN.
A Typ. Section - 3 Layers of Tires
Study Area "A"
Water Level
4' ± MIN.
A Typ. Section - 2 Layers of Tires
Study Area "B"
NOT TO SCALE
A
Typical Study Area
NOT TO SCALE
PROPOSED STUDY SITE
Sec: 18 Twp: 24 S. Rge: 37 E.
County of: Brevard Date: 11-21-72
Application by:
Sheet 1 of 2

Figure 3

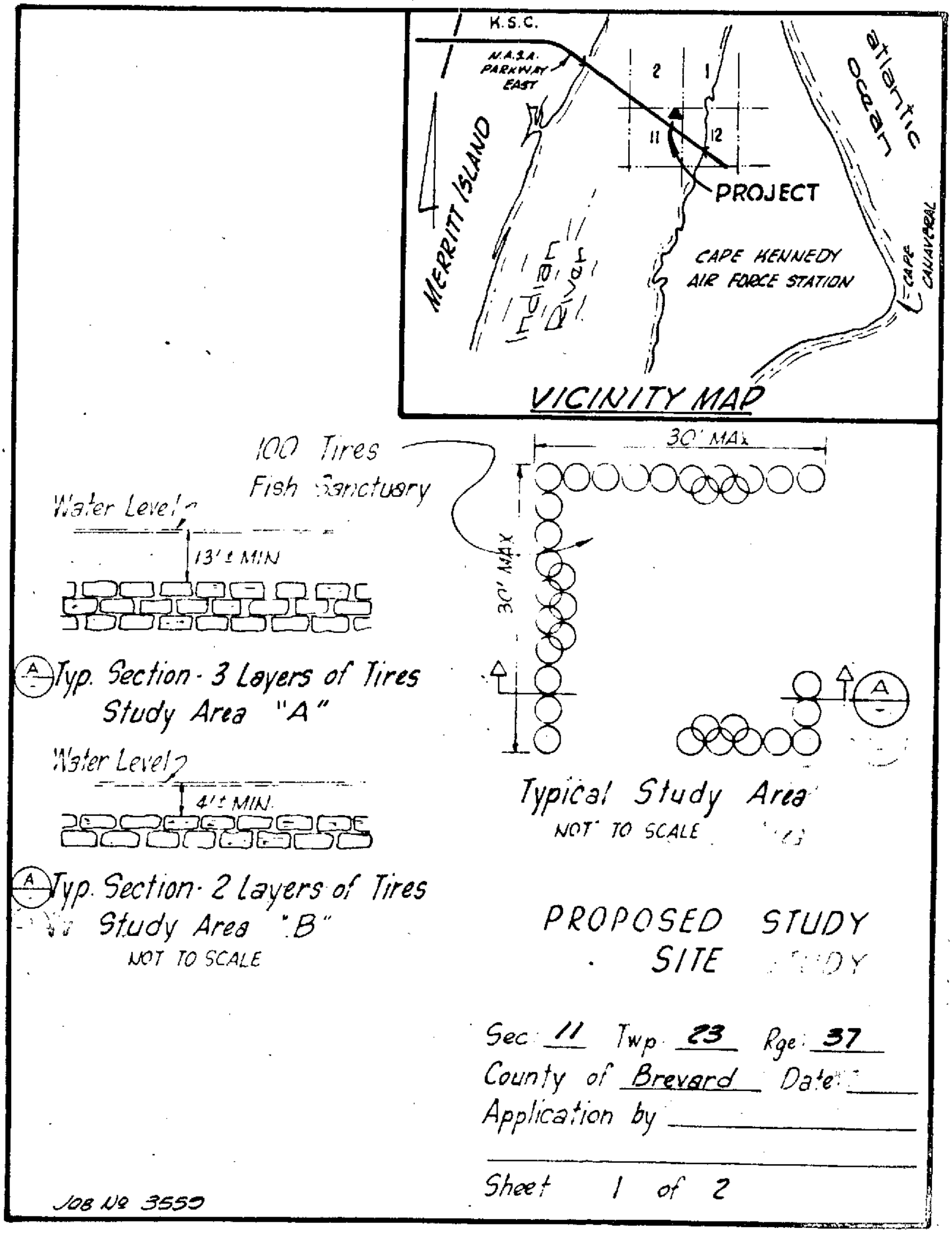

K.S.C.
N.A.S.A. PARKWAY EAST
2
1
11
12
PROJECT
atlantic ocean
MERRITT ISLAND
Indian River
CAPE KENNEDY AIR FORCE STATION
CAPE CANAVERAL
VICINITY MAP
100 Tires Fish Sanctuary
Water Level
13'± MIN
Typ. Section - 3 Layers of Tires Study Area "A"
Water Level
4'± MIN.
Typ. Section - 2 Layers of Tires Study Area "B"
NOT TO SCALE
30' MAX
30' MAX
Typical Study Area
NOT TO SCALE
PROPOSED STUDY SITE
Sec 11 Twp 23 Rge 37
County of Brevard Date
Application by
Sheet 1 of 2
JOB No 3559

Figure 4.1

Configuration of tire units

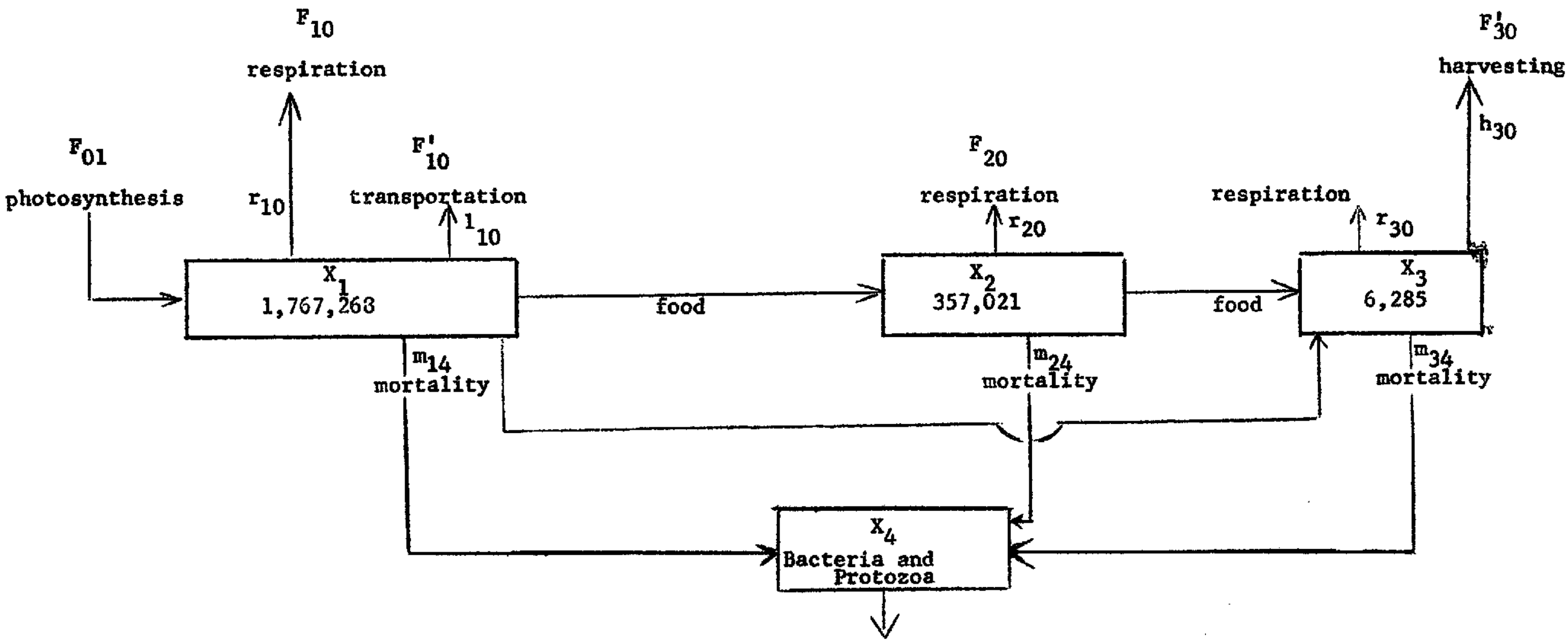
Transportation of tire units

Figure 5

PARTIAL ENERGY FLOW DIAGRAM

(Calories per m^2 per year)

Kelly's Park. Site A



13

Figure 4.2

Growth on tire units

Gamefish species which inhabit tire habitat

RESULTS AND DISCUSSION

Two methods of analysis were employed.

The data which were generated by the sampling techniques discussed previously were submitted to two general methods of analysis.

In the first method the purpose was to determine the degree of correlation which may exist between the relative frequencies of organisms which were found at three sites shown as A, B and C in Fig. 1. A significant positive correlation would indicate both that the sampling method was satisfactory and that there exists a reasonable measure of uniformity in the Biodynamics of the estuary within the limits of the sampling area which incidentally, extends over a distance of about 10 miles.

In the second method of analysis, the organisms were classified for convenience into three trophic levels and an attempt was made to show the relationship between the biomasses at the three levels.

Application of the data to an artificial habitat

An artificial reef of 17 three-tire units has been laid down at Site A and a similar reef is about to be laid down at Site B. The populations of organisms in and around these two reefs will be compared with populations which were there before reef establishment and those which will be found at Site C from time to time. Site C may be looked upon as a control for comparison with Sites A and B because, as will be shown further on, a significant positive correlation exists between the populations of organisms found at the three sites.

Correlation between populations at Sites A, B and C.

Table 1 contains the relative proportions of 38 species which were collected in seine samples at Sites A, B and C.

The organisms were ranked in order of relative frequencies and the resulting values were employed to determine Spearman's Rank Correlation Coefficient for each of the three possible combinations of sites. The results of the significance tests on the three correlation coefficients are given at the bottom of Table 1. It is shown there, that a highly significant correlation exists between frequencies of organisms at Sites A and B and at Sites B and C. An appreciable but non-significant correlation exists for Sites A and C. In general therefore, the frequencies at the three sites may be considered to be positively correlated.

Table 2 shows the frequencies of bottom organisms which were found at Sites A, B and C. All the correlation coefficients shown at the bottom of the table are highly significant. Therefore, as in the case of Table 1, it may be concluded that for the three sites, the frequencies of bottom organisms also, are strongly correlated positively.

Thus it would appear from a consideration of the data shown in Tables 1 and 2 that the distribution of the relative numbers of organisms over the approximately ten miles of the Estuary being studied, is fairly uniform. It may also be concluded that the sampling techniques employed in the study are satisfactory.

Relationships between the trophic levels.

The organisms which were sampled were classified into three broad trophic levels shown in Table 3. The divisions between the three groups may not be considered to be very sharp because there may be some within-group parasitism in levels X_2 and X_3. Also group X_1 provides food for members of X_3 in addition to X_2.

Tables 4, 5 and 6 present the biomasses at the three trophic levels on Sites A, B and C respectively. The biomass of X_2 expressed as a percentage of X_1, lies between 20% and 27%. Also, the biomass of X_1 expressed as a percentage of

X_2 lies between 1% and 2%. Thus, the relationship between the trophic levels is uniform throughout the area sampled.

The extent of productivity by the trophic level X_1 is below that reported by Ryther (21) for coastal zones. The biomass of X_2 is considerable due largely to the incidence of a good population of bottom organisms. It is about 1/5 of that X_1.

On the other hand, the biomass of X_3 is only about 1/50 that of X_2.

It would thus appear that the population of large fish and crabs is smaller than would be expected on the basis of available food. It would be expected that there should be larger populations of at least those species of fish which feed upon species such as oysters and barnacles. Such species of fish are _Lutjanus griseus_, _Archosargus probatocephalus_ and _Sciaenops ocellata_ which are all popular gamefish species.

A possible cause of reduction in numbers of gamefish is a high intensity of gamefishing. In order to provide for the high rate at which the existing stock is harvested out of the Estuaries, a logical step is to increase the type of habitat that is preferred by gamefish.

To this end, a small experimental tire habitat has been established at Site A in about 8' of water and another is about to be laid down at Site B at a similar depth.

No appreciable amount of data has accrued from the habitat at Site A but it has been observed that at both Sites A and B a healthy growth of organisms occurs on submerged automobile tires.

The upper pictures in Figure 5 show algae, oysters and barnacles which quickly appear on the surfaces of submerged tires. In addition large numbers of

Annelids, and other Arthropods and Molluscs soon establish themselves around the tires.

The lower picture in Figure 5 shows , two species of gamefish which readily occupy the tire havens.

Future experimental work.

The next stage of the present project would be to measure the populations of organisms around the havens for the purpose of comparing the values with those representing the rest of the Estuary. The aim of the observations will be to determine if the tire reefs provide conditions for population increase and if the populations of gamefish do increase in and around them as preliminary observations would indicate.

Some attention will also be directed towards a more complete understanding of the problem of energy flow within the ecosystem.

CONCLUSIONS

1. The structure of the biotic communities at the three sites, namely, Site A, Kelly's Park, Site B, NASA Causeway and Site C, Kennedy Area Recreation Center was found to be essentially similar measured by rank correlation of frequencies of organisms sampled at each site.

   The correlation coefficients between frequencies of seine samples were highly significant in two cases Sites A and B and Sites B and C. It was appreciable but not significant for Sites A and C.

   The correlation coefficients were highly significant for all three pairs of sites in the case of bottom organisms.

2. The relative biomasses at three arbitrary trophic levels at the three sites, were also quite similar, primary consumers being approximately 1/4 of the primary producers and secondary consumers being about 1/50 of primary consumers in terms of biomass.

3. The large biomass of bottom organisms favour the production of Sheepshead, Drum and Mangrove Snapper.

4. There are adequate food supplies for detritus feeders and species which dwell among grasses and algae.

5. The generally low populations of gamefish species may be due to intensive fishing and a high incidence of predators such as crabs and strongylura.

6. Submerged automobile tires develop a healthy growth of small animals and plants and attract gamefish species such as Sheepshead, Drum and Mangrove Snapper.

Table 1

Percentage composition of net samples taken at Sites A, B and C. October, 1972 - September, 1973

SPECIES	SITES A	SITES B	SITES C
Floridicthys carpio. Goldspotted killifish	7.62	8.68	8.94
Strongylura marina. Atlantic needlefish	1.43	.15	.33
Caranx hippos. Jack crevalle	.07	.00	.00
Syngnathus scovelli. Gulf pipefish	1.05	.83	.33
Menidia beryllina. Tidewater silverside	24.98	13.70	15.32
Brevoortia sp. Menhaden	.60	9.06	3.56
Anchova sp. Anchovy	3.92	.41	.08
Lagodon rhomboideus. Pinfish	2.94	.30	.16
Bairdiella chrysura. Silver perch	.67	.03	.25
Microgobius gulosus. Clown goby	.00	.15	.96
Mugil sp. Mullet	1.88	.86	1.59
Gobiosoma sp. Goby	.07	.71	.00
Eucinostomus sp. Mojarra	2.64	1.64	1.72
Shrimp	21.66	47.67	29.55
Archosargus probatocephalus. Sheepshead	.00	.03	.62
Oligopolites saurus. Leatherjack	.00	.00	.20
Poecilia latipinna. Sailfin molly	.00	.00	.37
Elops saurus. Ladyfish	2.49	.64	1.04
Fundulus grandis. Gulf killifish	.00	.00	.25
Chasmodes saburrae. Florida blenny	.00	.03	.00
Gobiosoma bosci. Naked goby	3.77	.15	.04
Lutjanus griseus. Mangrove snapper	.00	.07	.16
Haemulon macrostonum. W. I. Grunt	.00	.00	1.84
Porichthy sporosissimus. Atl. midshipman	.45	.03	.00
Raja eglanteria. Clearnose skate	.15	.11	.16
Galeicthys felis. Catfish	.22	.00	.04
Centropomus unidecimalis. Snook	.00	.00	.29
Scioenops ocellata. Channel bass	.00	.15	.00
Lucania parva. Rainwater killifish	15.92	13.02	24.51
Hippocampus zostrae. Pigmy seahorse	.15	.00	.00
Leiostomus xanthurus. Spot	6.25	.00	.00
Crabs	.75	.00	1.63
Opsanus beta. Toadfish	.15	.00	.62
Strongylura notata. Redfin needlefish	.00	1.13	.29
Diapterus olisthostomus. Irish pompano	.00	.00	.46
Haemulon plumieri. White grunt	.00	.00	1.46
Mugil cephalus. Black mullet	.00	.86	3.02
Drum	.07	.30	.04

Correlation coefficients and their significance

$r_{AB} = .538$ Significant at the 1% level

$r_{AC} = .233$ Not significant

$r_{BC} = .419$ Significant at the 1% level

Table 2

Frequency of bottom organisms per square metre
Sites A, B and C. October, 1972 - September, 1973

CLASSES OF ORGANISMS		SITES		
		A	B	C
Phylum Sipunculoidea.	Class Sipunculus	1.6	0.0	0.0
Phylum Annelida.	Class Polychaeta	18.4	12.7	0.3
Phylum Annelida.	Class Oligochaeta	0.2	0.0	0.0
Phylum Mollusca.	Class Gastropoda	7.6	11.3	18.3
Phylum Mollusca.	Class Pelecypoda	5.8	9.2	2.0
Phylum Mollusca.	Class Monoplacophora	1.2	0.2	0.0
Phylum Mollusca.	Class Scaphopoda	0.3	0.2	0.0
Phylum Mollusca.	Class Amphineura	0.1	0.0	0.0
Phylum Mollusca.	Class Phascolosoma	0.2	0.0	0.0
Phylum Echinodermata.	Class Ophiuroidea	0.8	2.8	1.0
Phylum Echinodermata.	Class Holothuroidea	2.9	1.5	0.8
Phylum Arthropoda.	Class Crustacea	2.2	2.0	0.6
Phylum Chordata.	Class Ascidiacea	0.0	0.0	0.0
Phylum Hemichordata.	Class Enteropneusta	0.3	0.3	0.3

<u>Correlation coefficients and their significance</u>

$r_{AB} = .840$ Significant at the 1% level

$r_{AC} = .712$ Significant at the 1% level

$r_{BC} = .869$ Significant at the 1% level

Table 3

GROUPING OF SPECIES INTO CONVENIENT TROPHIC LEVELS

Trophic level	Species
X_1	Phytoplankton, grasses, algae
X_2	Zooplankton Killifish, gobies, silversides, blennies, spot, anchovies, gambusias, minnows Shrimp Benthic animals Mullets, catfish, menhaden, pompano, skate
X_3	Drum, sheepshead, mangrove snapper, channel bass, toadfish, sailfin molly, grunt, leatherjack Snooks, pinfish, ladyfish, mojarra, perch Needlefish, seahorse, pipefish Crabs

Table 4

BIOMASSES AT KELLY'S PARK, SITE A

Trophic level	Species	gms D.M. per m^2	turnovers per yr.	Calories per mg. D.M.	Calories per m^2 per yr.
X_1	Phytoplankton	.468	365	2.4	409,968
	Grasses and algae	277.000	1	4.9	1,357,300
X_2	Zooplankton	.036	36	3.5	4,536
	Killifishes, etc.	.238	3	5.0	3,570
	Shrimp	.080	3	5.0	1,200
	Benthic animals	23.000	3	5.0	345,000
	Mullets, catfish, etc.	.543	1	5.0	2,715
X_3	Drum etc.	.386	1	5.0	1,930
	Snooks etc.	.345	1	5.0	1,725
	Needlefish etc.	.307	1	5.0	1,535
	Crabs etc.	.219	1	5.0	1,095

Table 5

BIOMASSES AT NASA CAUSEWAY, SITE B

Trophic level	Species	gms D.M. per m^2	turnovers per yr.	calories per mg. D.M.	calories per m^2 per year
X_1	Phytoplankton	.455	365	2.4	398,580
	Grasses and algae	229.299	1	4.9	1,123,565
X_2	Zooplankton	.030	36	3.5	3,780
	Killifishes etc.	1.336	3	5.0	20,040
	Shrimp	.193	3	5.0	2,895
	Benthic animals	24.909	3	5.0	373,635
	Mullets, catfish etc.	2.573	1	5.0	12,565
X_3	Drum etc.	.383	1	5.0	1,915
	Snooks etc.	.460	1	5.0	2,300
	Needlefish etc.	.016	1	5.0	80
	Crabs etc.	.006	1	5.0	30

Table 6

BIOMASSES AT KARS, SITE C

Trophic level	Species	gms. D.M. per m^2	turnovers per year	Calories per mg D.M.	Calories per m^2 per year
	Phytoplankton	.442	365	2.4	387,192
X_1	Grasses and algae	121.000	1	4.9	592,900
	Zooplankton	.019	36	3.5	2,394
	Killifishes, etc.	.494	3	5.0	7,410
X_2	Shrimp	.185	3	5.0	2,775
	Benthic animals	13.800	3	5.0	207,000
	Mullets, catfish, etc.	1.215	1	5.0	6,075
	Drum, etc.	.127	1	5.0	635
X_3	Snooks, etc.	.445	1	5.0	2225
	Needlefish, etc.	.008	1	5.0	40
	Crabs, etc.	.380	1	5.0	1900

ACKNOWLEDGEMENTS

Bethune-Cookman College takes this opportunity to express thanks to the National Aeronautics and Space Administration for the financial grant under which the present work is being carried out. Mr. Jurgen G. Pohly of the National Aeronautics and Space Administration, Washington, D. C., Mr. Raymond L. Norman, Mr. Frederick B. Schoenberger and Mr. Royce Hall of the John F. Kennedy Space Center have given much personal assistance during the conduct of the work. Other organizations which have given their cooperation are the Brevard County Commission, the Department of Public Works, the Florida Marine Patrol, Merritt Island Wildlife Refuge Management, the Department of Natural Resources, the Trustees of the Internal Improvement Trust Fund, the Army Corps of Engineers, the Brevard County Health Department and the Study Committee headed by Mr. Frederick B. Schoenberger.

My colleagues at Bethune-Cookman College who are responsible for enabling the student participants and classes in the Biological Sciences to obtain a full share of benefit from the project are Dr. Zoila R. Avalos and Dr. James G. Marlins.

The student participants at Bethune-Cookman College who carried out the field and laboratory work are Mr. Lorenzo A. Johnson, Mr. Kevin Gibson, Mr. Anthony P. Weston, Mr. Michael Lawrence, Mr. Jimmy Harvin, Mr. Charles G. Tanner, Miss Gayna Stevens, and Mrs. Nancy Fazekas. Mr. Royce Hall has been of particular help in the field operations.

The secretarial help provided by Mrs. Helen Wymes has been excellent.

Appendix 1

PERSONNEL

Supervisory and technical

Dr. P. Poonai. Principal Investigator

Dr. Zoila R. Avalos. Zoologist-vertebrate

Dr. J. Gregory Marlins. Zoologist-invertebrate

Mr. Royce Hall. Boat Captain and Diver

Mr. Raymond L. Norman. NASA Technical Officer, K.S.C.

Mr. Frederick B. Schoenberger. NASA Technical Officer, K.S.C.

Mr. Jurgen G. Pohly. NASA Technical Officer, Washington, D. C.

The Study Committee as shown on separate page.

Mrs. Helen Wymes. Secretary

Participating students

Mr. Lorenzo A. Johnson (Graduated)

Mr. Anthony Weston

Mr. Charles G. Tanner (Graduated)

Mr. Kevin R. Gibson

Mr. Jimmy C. Harvin

Mr. Michael Lawrence (Transferred to Michigan)

Mrs. Mildred Workman

Mr. Alonzo McQueen

Miss Janeth Harrison

Miss Gwendolyn Greene

Mr. V. Poonai

Classes of Botany, Ecology and Zoology

Consultants

Dr. Kerry Bruce Clark. Florida Institute of Technology

Dr. F. F. Snelson. Florida Technological University

Appendix 2

STUDY COMMITTEE

Mr. Frederick B. Schoenberger. K.S.C.

Mr. Raymond L. Norman. K.S.C.

Mr. Jurgen G. Pohly. Washington, D. C.

Mr. R. Cerrato. K.S.C.

Mr. W. L. Foss. K.S.C.

Mr. Hecker. K.S.C.

Mr. W. H. Lee. K.S.C.

Mr. K. Steel. K.S.C.

Mr. A. Hubbard. K.S.C.

Mr. Dan Evans. K.S.C.

Mr. R. Young. K.S.C.

Dr. James L. Baker. National Wildlife Refuge

Mrs. Cherie Down. Brevard County, Environmental Health

Mr. Richard B. Stone. Atlantic Estuarine Fisheries Center

Lieutenant Morgan. Florida Marine Patrol

Mr. David Dunsmoor. K.S.C.

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