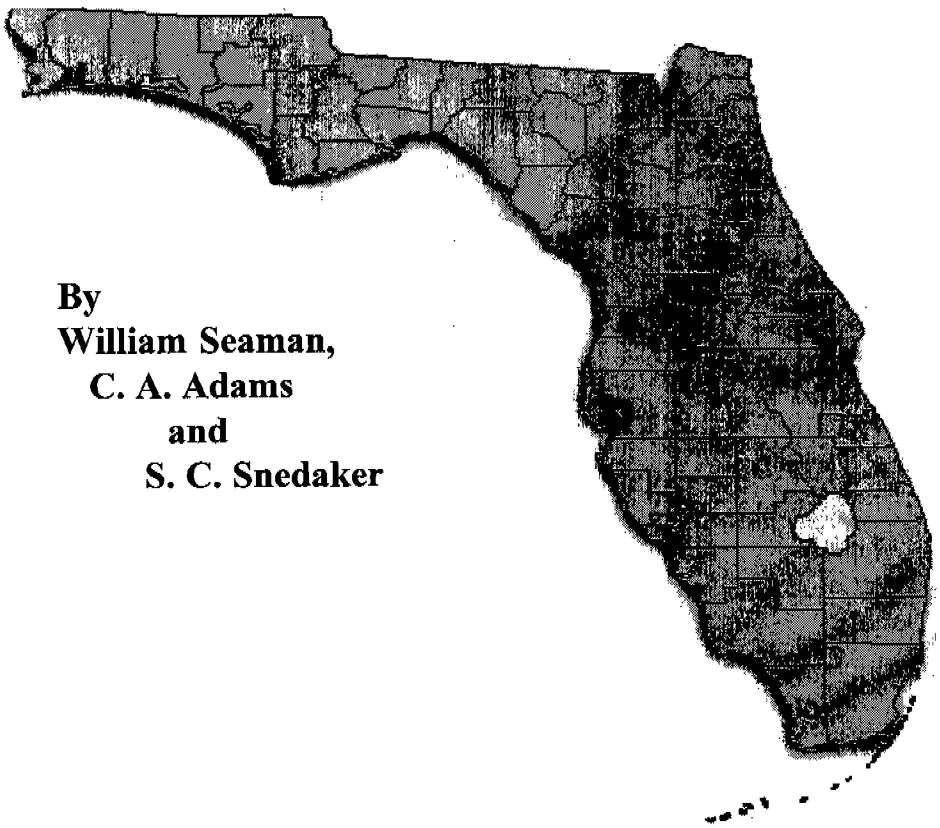
PB-231 748

The Role of Mangrove Ecosystems: Biomass Determinations in Shallow Estuaries -Technique, Evaluation and Preliminary Data



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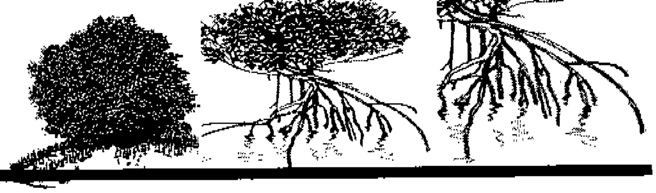

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16. Abstracts

A new type of portable drop net was developed and used to quantitatively harvest fishes from 16 m^2 sample areas in shallow estuaries. The technique is shown to be suitable for sedentary benthic and vegetation-inhabiting fishes, including eels, gobies, gerreids, syngathids, and juvenile pinfish, sciaenids, and flat fishes. The technique and preliminary results are evaluated and compared with reports in the literature describing techniques to estimate fish biomass.

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BIOMASS DETERMINATIONS IN SHALLOW ESTUARIES: TECHNIQUE EVALUATION AND PRELIMINARY DATA

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Introduction

Whereas generalized functions of estuaries (e.g., "nursery grounds") have been elucidated in recent years, little attention has been devoted to their quantification. That is, most studies to date have qualitatively described such phenomena as time of arrival of young fishes, or have expressed data in relative terms such as abundance on a catch-per-effort basis. To fully understand natural systems, it is necessary to go one step further and talk in terms of "how much". In Florida, for example, the species composition of estuaries is known, and many of the modes of species interactions (e.g., food webs, matter fluxes between coupled systems) are described. To determine the abundance of fishes in mangrove estuaries in southwest Florida this study was undertaken. As a prelude to such determinations it was necessary to evaluate and develop gear suitable for the necessary field work.

Many of the existing techniques for collection of fishes are acknowledged to be inadequate for quantitative faunal studies due to (1) selectivity for fishes of a certain size or behavior, and (2) expression of results as catch-per-unit of effort when effort is subject to large variability. Although many techniques are useful

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in monitoring an environment when they are employed by the same investigator over time, utility of the results in making comparisons with other studies is questionable. In part, criticism of techniques is due to their design as devices for straining organisms out of an open-sided water column.

As an alternative, this study sought methods based on the concept of complete enclosure of a water column to (1) prohibit fish escapement and (2) establish a collection area of defined dimensions. Enclosure and harvest of water columns are embodied in the commercial purse seine, and the concept has been applied in scientific studies, most notably in Texas.

In Texas, fish biomass has been quantified using a helicopter-borne purse net (Jones et al., 1963), a beach seine (McFarland, 1963), and drop nets (Hellier, 1958, 1962; Hoese and Jones, 1963; Moseley and Copeland, 1969). The first drop nets employed were permanent and had the disadvantages of (1) disturbing the habitat with repeated seining to harvest the enclosed water column (118 m^2); (2) escape of small specimens (stretched mesh, 19 mm); and (3) requiring some surveillance. The latter drop net was portable, yet the somewhat complex construction and possible loss of benthos under the pursing lead line may be disadvantageous. Because of this, the concept of the drop net was redesigned as described below. Because significant effort was directed in this study on refining gear and techniques, comparison with previous quantitative methods is made.

Methods

Drop net

A 4 x 4 m portable drop net was designed, constructed, and employed in this study. The frame was built of three-inch (ID) diameter PVC pipe as ten-foot tall corner posts, which supported 4-inch (ID) diameter 4.5 meter long crosspieces (Figure 1). From the crosspieces was suspended a 1/16" square mesh, 6-foot deep net. A chain weighing one pound per linear foot was used as a lead line.

Working from a boat the frame can be assembled and net hung and rigged in no more than one hour. The corner posts are driven into the substrate, crosspieces lowered down them and supported by 1/4" diameter surveyor pins at any height desired (Figure 2), and the net is then paid out along the perimeter of the study site. The net is attached to the crosspiece at 3 foot intervals and the chain line is stretched and slipped over the trigger pins at each corner (Figure 3). The ends of the net are joined by a Velcro (R) nylon fastener. Lines are run from each trigger to a common point outside the frame, joined, and the common trigger line is run to a stake at least 100 feet from the drop net. After acclimation of at least one hour the trigger rope is pulled from the stern of a rapidly accelerating outboard skiff.

As soon as the net is triggered the lead line is tamped into the substrate to insure enclosure of the bottom of the water column. Two people then enter the enclosure, stretch a 1/16" square mesh seine between the sides, and seine from one end of the enclosure to the other (Figure 4). Repeated seine hauls are made until two consecutive empty hauls are recorded.

Collections are preserved in 20% formalin in the field. Synoptic data are recorded.

Enclosure net

To complement the drop net an 820-foot long, 8-foot deep net (1/4" square mesh) was employed to enclose a pre-determined rectangular area. The net was rapidly paid out of a skiff. The water column was then harvested by repeatedly pulling a 150-foot long, 6-foot deep, 1" stretch mesh seine the entire length of the enclosure, just as done for the drop net. In contrast to the drop net, a total harvest was not attempted; rather, the principle of "diminishing returns" was applied to the fishes collected.

Field sites

Collection sites were selected in Fahka Union and Fahkahatchee Bays, Collier County (Figures 5 and 6) to represent dominant benthic subsystems: grass beds, algae beds, and bare substrate (i.e., mud, sand, shell). Drop net work was started in February, 1972, and the enclosure net was used in September, 1972. All collections were made during daylight hours. Under favorable conditions, two or three collections per day are possible.

Post-field processing

After initial field preservation in 20% formalin specimens were washed into 70% isopropyl alcohol. Stronger than "usual" solutions were used to insure preservation of stomach contents for dietary analysis.

In the laboratory specimens were sorted by species. To determine biomass, number of individuals and total weight (patted dry) by species were recorded. Also, length and weight of individual specimens were determined.

Results

Field work was conducted at two times of the year: late winter and late summer. The first period of field work, 26 February-31 March, 1972, was devoted exclusively to drop net collections, whereas drop net and enclosure nets were employed 20-28 September 1973.

All collections combined yielded 53 species of fishes (Table 1).

Analysis of the data is based on determination of which species are accurately (quantitatively) sampled by either technique. That is, the 53 species are not uniformly amenable to different collecting techniques; the complete records of harvests from drop nets (Tables 2-5) and the enclosure net (Carter et al., 1973)are summerized in Tables 6 and 7, which reflect the suitability of different age, size, and behavior individuals for capture by either technique.

In assigning a species to quantification by either technique or discounting it as unsuitable for the two techniques, smaller, less mobile, non-schooling, or benthic fishes (eels, killifishes, syngnathids, gerreids, gobies, some flatfishes) were classified as "drop net" forms. Larger, more mobile, or schooling fishes (adult snook, snapper, etc.) were classified as "enclosure net" forms.

Drop nets

All the raw drop net data are presented in Tables 2-5 and are summarized in Table 6. In Table 6 mean biomass values for the species accurately quantified by the drop net are listed. Those species are characterized as being either (1) sedentary adults, either pelagic or benthic, including the Syngnathidae and Gobiidae, or (2) randomly distributed juveniles such as the gerreids, sparids, and sciaenids. Data on large mobile adults (such as sting rays) were not included in Table 6.

Of the comparisons possible in analyzing the data seasonal trends within a bay, and spatial trends between and within bays are made. In the dry season (winter) unvegetated bottom in Fahkahatchee Bay supports a larger biomass, primarily due to the abundance of pinfish and silver perch.

Seasonally, biomass was greater in the late summer, and in Fahkahatchee Bay relative biomass increased over grass beds and declined in the unvegetated subsystem.

Enclosure net

Complete summaries of the collections made using the enclosure net are presented in the final report of the Environmental Protection Agency (Carter et al., 1973). In this paper the data have been reduced to account for the biomass that is quantitatively estimated with high confidence. In Table 7 therefore the species listed are those collected in a pattern of diminishing returns. Furthermore these collections complement the drop net collections in providing a minimal estimate of biomass of larger and/or more mobile species.

Whereas fewer species were collected in Fahka Union Bay, biomass was greater for the one subsystem sampled in both bays. The difference in biomass in the algae system was accounted for primarily by snook, snapper, and sheepshead.

Within Fahka Union Bay, two species (ladyfish and catfish) account for nearly all of the biomass over unvegetated bottom.

Combined techniques

In Table 8 biomass data from both the drop net and enclosure net are summarized. Unvegetated bottom in Fahka Union Bay supported in late summer a biomass exceeding 10 grams/m^2 (wet weight), whereas the grass-dominated subsystem in Fahkahatchee Bay supported biomass exceeding

9 grams/m^2. In both subsystems "forage species" including gerreids, pinfish, and silver perch comprised a significant portion of the biomass.

Discussion

Of the 53 species of fishes collected in this study, 46 were quantified by the techniques employed. That is, biomass of 28 species was determined by the drop net, 18 by enclosure net, and 7 species -- notably *Dasyatis sabina*, *Anchoa* spp., and *Mugil* spp. -- could not be quantified. It is important to note, however, that different stages of the life cycle of a given species may be differentially susceptible to capture by any one technique. This situation of course parallels the shift in ecological role a species may exhibit as it matures. For the most part smaller fishes including juveniles and small adults and benthic forms appear in the drop net, whereas adults or more mobile forms are most accurately quantified by the enclosure net.

The drop net alone yields biomass estimates that compare favorably with other water column enclosure techniques (Table 9). Its advantages include portability and a relatively low cost of construction. It is somewhat labor intensive, in that a three-man crew can effectively make a maximum of three collections per day.

The fact that perhaps 90% of the biomass of combined collections (Table 8) is attributable to the drop net reflects the dominance of juvenile, small, and/or benthic fishes in the Ten Thousand Islands mangrove estuaries.

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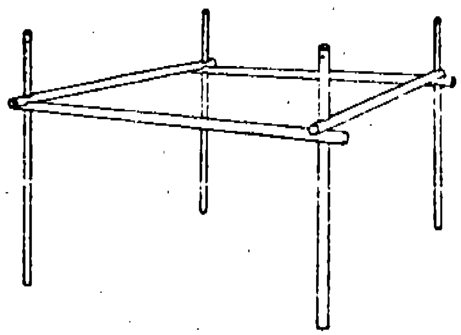

Figure 1. - Portable drop net frame assembly.

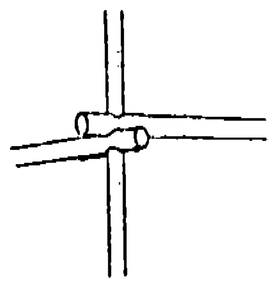

Figure 2. - Corner assembly of drop net frame, with support pin inserted.

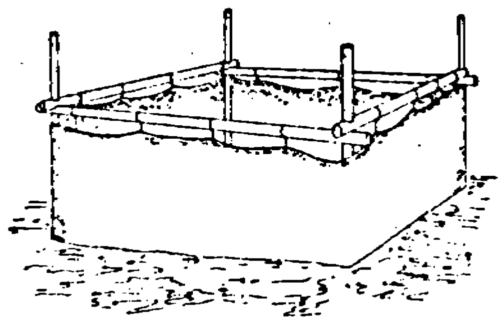

Figure 3. - Drop net suspended from frame.

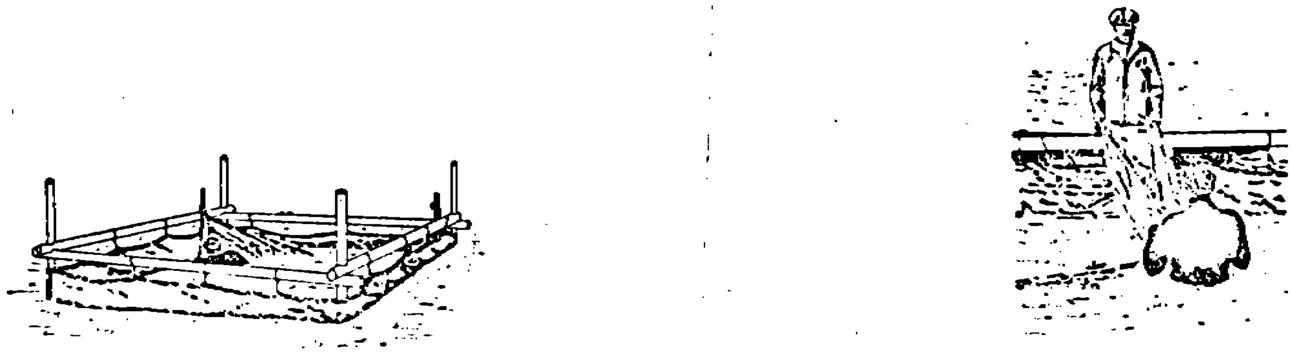

Figure 4. - Harvesting the drop net enclosure.

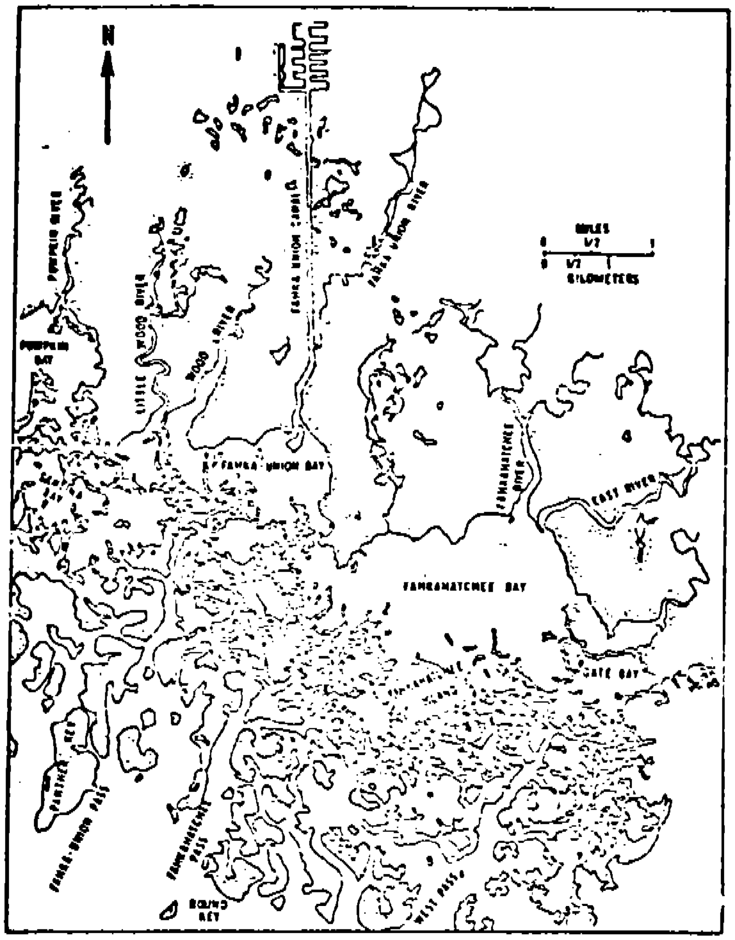

Figure 5. - Map of southwest Florida; that portion of Collier County showing relative locations of Fahka Union and Fahkahatchee Bays.

Table 1. - Seasonal occurrence of fishes in Fahkahatchee-Fahka Union quantitative collections≠

Species*	Date: Feb.-Mar. 1972	Date: Sept. 1972
Dasyatis sabina	D	D,E
Elops saurus		D,E
Myrophis punctatus	D	D
Brevoortia smithi		E
Harengula pensacolae		E
Opisthonema oglinum		E
Anchoa hepsetus	D	D,E
Anchoa mitchilli	D	D,E
Anchoa sp. (cf *hepsetus* or *mitchilli*)		D,E
Synodus foetens	D	D,E
Arius felis		E
Opsanus beta		D,E
Ogilbia cayorum		D
Hyporhamphus unifasciatus		E
Strongylura notata		E
Strongylura timucu		E
Cyprinodon variegatus	D	D
Fundulus sp.	D	D
Lucania parva	D	D
Hippocampus zosterae		D
Hippocampus sp. (cf *erectus* or *zosterae)*		D
Micrognathus crinigerus		D
Syngnathus floridae		D
Syngnathus scovelli	D	D,E
Syngnathus sp. (cf *floridae* or *scovelli*)		E
Centropomus undecimalis		E
Chloroscombrus chrysurus		D
Oligoplites saurus		E
Lutjanus griseus		E
Diapterus plumieri	D	D,E
Eucinostomus argenteus	D	D,E
Eucinostomus gula	D	D,E
Eucinostomus lefroyi		D,E
Eucinostomus sp. (cf *argenteus* or *gula*)	D	D,E

Table 1 (cont'd)

Species*	Date Feb.-Mar. 1972	Sept. 1972
Haemulon sp.		D
Orthopristes chrysoptera		D,E
Archosargus probatocephalus	D	D,E
Lagodon rhomboides	D	D,E
Bairdiella chrysura	D	D,E
Cynoscion nebulosus		D,E
Leiostomus xanthurus	D	D
Mugil cephalus		E
Sphyraena		E
Chasmodes saburrae		E
Gobionellus smaragdus	D	D
Gobiosoma bosci	D	D,E
Gobiosoma robustum	D	D,E
Microgobius gulosus	D	D,E
Microgobius thalassinus	D	D
Scomberomorus maculatus		E
Prionotus scitulus	D	D
Etropus crossotus		E
Paralichthys albigutta	D	D,E
Achirus lineatus	D	D,E
Trinectes maculatus		D
Symphurus plagiusa	D	D,E
Sphoeroides nephelus		E

≠ D = collected with drop net; E = collected with enclosure net

* Phylogenetic arrangement

Table 2. - Spatial distribution of drop net collections in Fahka Union, Feb.-Mar. 1972; all species (grams/16 m^2)

Subsystem:	Bare	Bare	Oyster	Mud	Mud	Mud
Date:	2/29	3/2	3/3	3/3	3/4	3/13
Collection #:	4	5	6	7	10	11
Dasyatis sabina				8.1		
Anchoa hepsetus		0.2	0.9			0.1
Anchoa mitchilli					16.0	
Synodus foetens	0.5				0.8	
Syngnathus scovelli					0.1	0.4
Eucinostomus argenteus			6.2		35.2	
Eucinostomus gula			1.8		24.7	
Lagodon rhomboides			1.3			
Gobionellus smaragdus				2.0		
Gobiosoma robustum				0.4	0.5	0.3
Microgobius gulosus					6.8	
Microgobius thalassinus					1.9	
Prinotus scitulus		1.3				
Symphurus plagiusa					2.7	
No. Spp.	1	2	4	3	9	3
Total Wt.	0.5	1.5	10.2	10.5	88.7	0.8

Table 3. - Spatial distribution of drop net collections in Fahkahatchee, March, 1972; all species (grams/16 m^2)

Subsystem:	Bare	Mud	Mud	Mud	Mud	Grass	Algae
Date:	3/31			3/28	3/28	3/14	3/20
Collection #:	27	16	17	20	21	13	24
Dasyatis sabina		706.4					
Myrophis punctatus		3.7		2.5	10.7		2.5
Anchoa hepsetus						0.1	
Anchoa mitchilli		5.9					
Synodus foetens			2.1	1.3			
Cyprinodon variegatus							0.8
Fundulus sp.							0.3
Lucania parva		2.0					
Syngnathus scovelli		0.5	0.1	1.1	4.7	0.4	
Diapterus plumieri							233.4
Eucinostomus argenteus	10.5	3.2	8.1	4.8	14.6		19.7
Eucinostomus gula		38.8	21.0		8.4		
Eucinostomus sp.							0.1
Archosargus probatocephalus					1.3		
Lagodon rhomboides				13.6	27.1		
Bairdiella chrysura		0.1		0.5	6.3		
Leiostomus xanthurus							0.4
Gobionellus smaragdus				6.2	11.8		
Gobiosoma bosci			0.3	0.2	1.9		
Gobiosoma robustum			0.5	0.2	0.1	0.3	
Microgobius gulosus		2.2	0.9	6.8	2.1		
Microgobius thalassinus				0.5			
Prionotus scitulus			0.7				
Paralichthys albigutta					0.5		
Achirus lineatus		0.6	0.2	3.1	2.2		
Symphurus plagiusa		1.4	4.2	5.7			
No. Spp.	1	11	10	13	13	3	7
Total Wt.	10.5	764.8	38.1	46.5	91.7	0.8	257.2

Table 4. - Spatial distribution of drop net collections in Fahka Union, Sept. 1972; all species (grams/16 m^2)

Subsystem:	Bare	Bare	Bare	Bare	Grass
Date:	9/17	9/25	9/27	9/28	9/25
Collection #:	11	8	12	14	7
Myrophis punctatus		8.1	5.2	4.8	2.0
Anchoa hepsetus			8.3		
Anchoa mitchilli				5.0	
Synodus foetens	0.4				
Opsanus beta		2.0			
Ogilbia cayorum			0.4		
Lucania parva		0.8			
Hippocampus zosterae		0.1			
Syngnathus floridae		0.7			
Syngnathus scovelli		4.2		0.7	
Eucinostomus argenteus		25.9		9.9	
Eucinostomus gula	2.8	21.5			
Eucinostomus sp. (cf *argenteus* or *gula*)		4.8			0.1
Lagodon rhomboides		171.6			
Bairdiella chrysura		283.0			1.1
Cynoscion nebulosus		1.8		0.7	
Gobionellus smaragdus			1.9		
Gobiosoma robustum	1.1	0.7	0.3	2.4	0.1
Microgobius gulosus	0.1	1.5	4.9	1.3	1.0
Microgobius thalassinus			0.7	0.1	
Achirus lineatus		1.7	0.2		
Symphurus plagiusa		6.8	9.4	7.9	
No. Spp.	4	16	9	9	5
Total Wt.	4.4	535.2	31.3	32.8	4.3

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Table 5. - Spatial distribution of drop net collections in Fahkahatchee, Sept. 1972; all species (grams/16 m^2)

Subsystem:	Bare	Bare	Bare	Grass	Grass	Grass	Grass
Date:	9/20	9/21	9/22	9/22	9/24	9/26	9/26
Collection #:	1	2	3	4	6	9	10
Elops saurus						122.8	
Myrophis punctatus	16.3	2.8		8.3	5.7	21.1	1.6
Anchoa mitchilli	35.1	7.0	4.1		32.3		3.8
Anchoa sp.		3.5			0.1		
Synodus foetens					0.6		
Opsanus beta		0.8					
Hippocampus zosterae					0.5		
Hippocampus sp.	0.1						
Micrognathus crinigerus	0.2						
Syngnathus scovelli	3.6	0.6	0.2	0.2	2.1	1.1	1.3
Chloroscombrus chrysurus					0.1		
Eucinostomus argenteus	14.1		4.6				
Eucinostomus gula			12.0	33.5	41.1	14.1	15.6
Eucinostomus lefroyi							0.1
Eucinostomus sp.		7.9	2.4	6.1	2.5	1.7	13.2
Haemulon sp.	15.5						
Orthopristes chrysoptera					24.1		
Lagodon rhomboides					162.2	12.3	14.2
Bairdiella chrysura	0.3				110.8	4.4	0.1
Cynoscion nebulosus	1.3				22.2		0.1
Gobionellus smaragdus	6.9	2.8				0.3	
Gobiosoma robustum	3.3	0.6		0.3	4.9	2.6	3.3
Microgobius gulosus	9.8	6.1		2.7	11.0	5.9	0.9
Achirus lineatus	1.5	1.3			0.8	2.8	0.5
Trinectes maculatus	0.6						
Symphurus plagiusa	2.4	2.9		0.4	3.2	4.8	0.1
No. Spp.	15	11	5	7	17	12	13
Total Wt.	111.0	36.3	23.3	51.4	424.2	193.9	54.8

Table 6. - Biomass (g/16m²) of fishes for which drop net provides valid information.

Species	Feb.-Mar. 1972 Fahka Union Bare (6)	Feb.-Mar. 1972 Fahka Union Grass (0)	Feb.-Mar. 1972 Fahka Union Algae (0)	Feb.-Mar. 1972 Fahkahatchee Bare (5)	Feb.-Mar. 1972 Fahkahatchee Grass (1)	Feb.-Mar. 1972 Fahkahatchee Algae (1)	Sept. 1972 Fahka Union Bare (4)	Sept. 1972 Fahka Union Grass (1)	Sept. 1972 Fahka Union Algae (0)	Sept. 1972 Fahkahatchee Bare (3)	Sept. 1972 Fahkahatchee Grass (4)	Sept. 1972 Fahkahatchee Algae (0)
Myrophis punctatus				3.30		2.50	4.52	2.0		6.37	9.17	
Synodus foetens	0.22			0.68			0.10				0.25	
Ogilbia cayorum?							0.10					
Cyprinodon variegatus						0.80						
Fundulus sp. (juvenile)						0.33						
Lucania parva				0.40			0.20					
Hippocampus zosterae							0.03				0.13	
Hippocampus sp. (cf *erectus* or *zosterae*)										0.03		
Micrognathus criniger										0.07		
Syngnathus floridae							0.20					
Syngnathus scovelli	0.82			1.08	0.40		1.22			1.47	1.30	
Eucinostomus argenteus	6.90			8.24		19.70	8.95			6.25		
Eucinostomus gula	4.40			13.64			6.07			4.00	26.07	
Eucinostomus lefroyi											0.03	
Eucinostomus sp. (cf *argenteus* or *gula*)						0.10	1.20	0.1		3.43	5.87	
Haemulon sp. (juvenile)										5.17		
Orthopristes chrysoptera											6.03	
Archosargus probatocephalus				0.26								
Lagodon rhomboides	0.21			8.12			42.90				47.17	
Bairdiella chrysura				1.38			70.75	1.1		0.10	28.83	
Gobionellus smaragdus	0.33			3.60			0.48			3.23	0.08	
Gobiosoma bosci				0.48								
Gobiosoma robustum	0.20			0.16	0.30		1.12	0.1		1.30	2.78	
Microgobius gulosus	1.13			2.40			1.95	1.0		5.30	5.12	
Microgobius thalassinus	0.31			0.10			0.20					
Prionotus scitulus	0.21			0.14								
Achirus lineatus				1.82			0.48			0.93	1.03	
Trinectes maculatus										0.20		
Symphurus plagiusa	0.45			2.26			6.02			1.77	4.12	
TOTAL (g/16m²)	15.13	-	-	48.06	0.70	21.43	146.49	4.3	-	39.62	137.98	-
Biomass/m²	0.95	-	-	3.00	0.04	1.46	9.13	0.27	-	2.48	8.62	-

Table 7. Biomass (g/m^2) of fishes for which enclosure net provides valid information, September, 1972.

		Fahka Union			Fahkahatchee		
	Subsystem:	Bare	Grass	Algae	Bare	Grass	Algae
Species	# Collections:	2	0	1	0	2	1
Elops saurus		.54		.06			
Brevoortia smithi						.01	
Harengula pensacolae						.01	
Opisthonema oglinum						.02	
Arius felis		.50		.05			
Opsanus beta						.13	.10
Hyprhamphus unifasciatus		.03					.01
Strongylura notata							.01
Strongylura timucu							.05
Centropomus undecimalis				.85			.25
Oligoplites saurus							.01
Lutjanus griseus				.54		.21	.02
Diapterus plumieri				.44			.24
Archosargus probatocephalus				.35			.03
Cynoscion nebulosus		.01				.07	.12
Sphyraena barracuda							
Scomberomorus maculatus		.04					
Sphoeroides nephelus				.02		.06	
	TOTAL	1.12	-	2.31	-	.51	.84

Table 8. Total fish biomass for species quantified by either drop net or enclosure net.

	Mean biomass (g/m^2)											
	Feb.-Mar., 1972						Sept., 1972					
Location:	Fakha Union			Fahkahatchee			Fakha Union			Fakahatchee		
Collector / Subsystem:	Bare	Grass	Algae	Bare	Grass	Algae	Bare	Grass	Algae	Bare	Grass	Algae
Drop Net	0.95	---	---	16.00	0.04	1.46	9.13	0.27	---	2.48	8.62	---
Enclosure Net	---	---	---	---	---	---	1.12	---	2.31	---	0.51	0.84
TOTAL	---	---	---	---	---	---	10.25	---	---	---	9.13	---

Table 9. Comparison of water column enclosure techniques employed in marine environments.

Technique (& Reference)	Area Enclosed (m^2)	Net Stretch Mesh (in.)	Mean Biomass (g/m^2)
Drop net (Hellier, 1958)	252.9	3/4	6.1
Drop net (Hellier, 1958)	1011.7	3/4	16.6
Drop net (Hellier, 1958)	1011.7	3	2.9
Drop net (Hesse & Jones, 1963)	118	1	<5.0*
Purse seine (Jones et al., 1963)	100.4	3/4	12.16
Beach seine (McFarland, 1963)	4450.5	3/4	17.47
Portable drop net -- this study	16	1/8	16.00*
Enclosure net -- this study	1840	½	2.31*

*Maximum mean