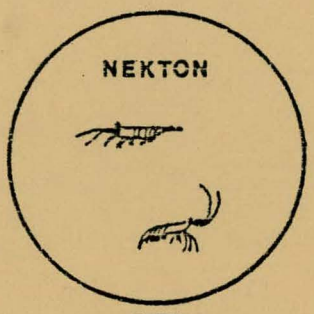
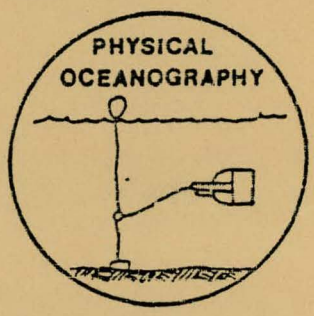
EVALUATION OF BRINE DISPOSAL FROM THE BRYAN MOUND SITE OF THE STRATEGIC PETROLEUM RESERVE PROGRAM





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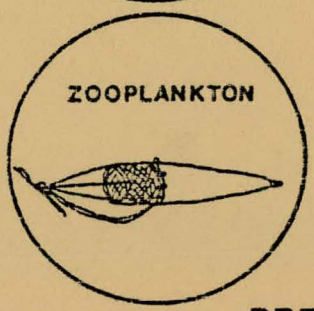

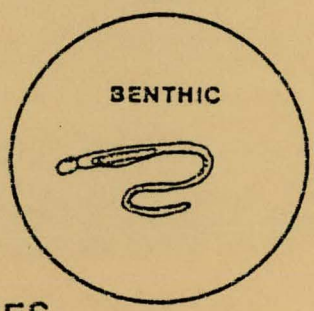

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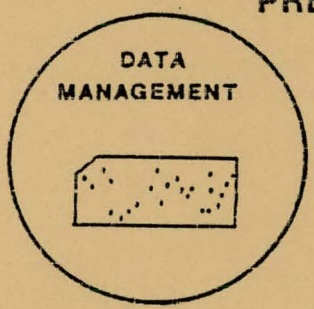

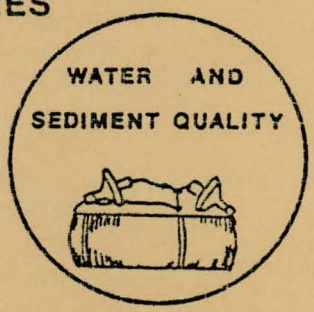

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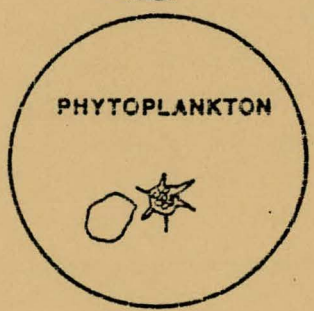

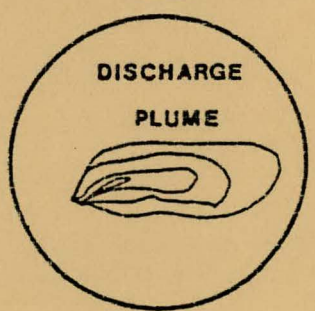

CHAPTER 4
APPENDIX 7

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EVALUATION OF BRINE DISPOSAL FROM THE BRYAN MOUND SITE OF THE STRATEGIC PETROLEUM RESERVE PROGRAM

Final Report of Predisposal Studies

Chapter 4

Appendix 7

Draft Report -- June 1980

Final Report -- February 1981

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CHAPTER 4

NEKTON

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4.1 Introduction

Coastal waters of the Gulf of Mexico off Freeport, Texas will become the receiving site for brine discharge from underground salt domes being leached to provide space for crude oil as part of the Strategic Petroleum Reserve Program of the U.S. Department of Energy. Environmental assessment prior to discharge is needed to provide a background against which effects of brine disposal can be measured.

This chapter describes the nekton communities off Freeport during the predisposal period of October 1977-February 1980. Descriptions of the nekton communities form two logical groupings of the chapter sections. An initial grouping (Sections 4.3-4.10) describes a broad picture for the nekton along the continental shelf off Freeport to a depth of 25 fathoms. A latter grouping (Sections 4.11-4.17) analyzes in greater detail the nekton community in a smaller study area made up of stations located in depths of 12 fathoms near the diffuser.

Cruise tracks, collection and processing procedures, objectives, experimental design, and analytical procedures are described in Section 4.2. The following sections (4.3-4.10) then describe a broad picture of the nekton along the continental shelf to include a summary and analysis of overall species compositions (4.3) and diel variation in catch

compositions (4.4), species compositions in broad cross-shelf areas and delineation of station sets using cluster analysis (4.5), trends in abundance by station and depth (4.6), monthly trends in abundance (4.7), species compositions by season and month in each broad cross-shelf area (4.8), effects of low dissolved oxygen conditions on nekton (4.9), and comments on the occurrences of red drum and black drum in the study area (4.10). Thereafter, the following sections (4.11-4.18) describe a detailed picture of nekton communities near the diffuser site to include a summary and analysis of overall species compositions (4.11), diel variation in catch compositions (4.12), species compositions by station (4.13), species compositions by season and month (4.14), analysis of variance evaluations of monthly and among stations trends in abundance for the total Penaeid shrimp community (4.15) and for the total fish community (4.16), and an analysis of among stations homogeneity in size compositions of important nekton (4.17). A final section (4.18) integrates, discusses, and summarizes the findings.

4.2 Materials and Methods

Nekton collections were made aboard chartered commercial shrimp trawlers off Freeport, Texas from October 1977 through February 1980. Details of the cruises, cruise tracks and procedures in that time period follow.

4.2.1 Cruises Completed and Cruise Tracks

Cruises completed during the period October 1977-February 1980 include almost monthly collections in the period October 1977-October

1978 and almost twice-monthly collections in the period December 1978-February 1980. Tables 4-1 and 4-2 summarize when cruises were made and the stations occupied. Cruises in the period October 1977-September 1978 made only daytime collections. Cruises thereafter made daytime or nighttime collections, but not both on a given cruise. Table 4-3 summarizes cruise dates, diel time periods when trawling was done, and vessels employed. Table 4-4 and Figure 4-1 summarize the station positions.

Collections in the period October 1977-June 1978 focused on the then planned inshore diffuser site. Regular collections in that period were made only at stations 1-13 inclusive, and duplicate tows were made only at stations 3-8.

The cruise track was modified commencing in July 1978 to focus on an offshore diffuser site hereinafter designated as the diffuser area. Stations 4, 7, and 13 were discontinued commencing in July 1978 and were replaced by duplicate tows at stations 14, 15, 16 and 17 positioned astride the diffuser location. Commencing in December 1978, the cruise track was extensively changed. A series of new stations, and continued old stations, formed a transect perpendicular to shore that provides background information on the nekton. Stations along this transect include stations A, 1, 2, 3, 5, 6, 8, 9, 10, 11, 12, and 26. A second group of stations were continued or established in the diffuser area including stations 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, and 25. Duplicate tows were made, if possible, at all stations commencing in December 1978 (Tables 4-1, 4-2).

Station depths are summarized in Table 4-4. The observed mean depth was calculated from all records in the period October 1977-May 1979.

Table 4-1. Summary of the cruises and collections made in the area of the offshore diffuser. The "x" symbols indicate that collections were made; dashes indicate that no collections were made. The symbol "D" represents daytime collections, and the symbol "N" represents nighttime collections. No collections were made in this area prior to July 1978.

	1977			1978							
Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
14a	-	-	-	-	-	-	-	-	-	x	-
14b	-	-	-	-	-	-	-	-	-	x	-
15a	-	-	-	-	-	-	-	-	-	x	-
15b	-	-	-	-	-	-	-	-	-	x	-
16a	-	-	-	-	-	-	-	-	-	x	-
16b	-	-	-	-	-	-	-	-	-	x	-
17a	-	-	-	-	-	-	-	-	-	x	-
17b	-	-	-	-	-	-	-	-	-	x	-
18a	-	-	-	-	-	-	-	-	-	-	-
18b	-	-	-	-	-	-	-	-	-	-	-
19a	-	-	-	-	-	-	-	-	-	-	-
19b	-	-	-	-	-	-	-	-	-	-	-
20a	-	-	-	-	-	-	-	-	-	-	-
20b	-	-	-	-	-	-	-	-	-	-	-
21a	-	-	-	-	-	-	-	-	-	-	-
21b	-	-	-	-	-	-	-	-	-	-	-
22a	-	-	-	-	-	-	-	-	-	-	-
22b	-	-	-	-	-	-	-	-	-	-	-
23a	-	-	-	-	-	-	-	-	-	-	-
23b	-	-	-	-	-	-	-	-	-	-	-
24a	-	-	-	-	-	-	-	-	-	-	-
24b	-	-	-	-	-	-	-	-	-	-	-
25a	-	-	-	-	-	-	-	-	-	-	-
25b	-	-	-	-	-	-	-	-	-	-	-

Table 4-1. Continued

Station	1978 Sept.	Oct.		Nov.		Dec.		1979 Jan.		Feb.		Mar.		Apr.		May	
		N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
14a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
14b	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
15a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
15b	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
16a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
16b	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
17a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
17b	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
18a	-	-	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-
18b	-	-	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-
19a	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
19b	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
20a	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
20b	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
21a	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
21b	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
22a	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
22b	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
23a	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
23b	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
24a	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
24b	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
25a	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-
25b	-	-	-	-	-	-	x	-	-	-	x	x	-	x	x	x	-

Table 4-1. Continued

Station	1979 June N	June D	July N	July D	Aug. D	Sept. D	Oct. N	Oct. D	Nov. N	Nov. D	Dec. N	Dec. D	1980 Jan. N	Jan. D
14a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
14b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
15a	x	-	x	-	x	-	x	x	-	x	x	x	-	x
15b	x	-	x	-	x	-	-	x	-	x	x	x	-	-
16a	x	-	x	-	x	x	x	x	-	x	x	x	-	x
16b	x	-	x	-	x	x	x	x	-	x	x	x	-	x
17a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
17b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
18a	x	-	x	-	x	x	x	x	x	x	x	x	x	x
18b	x	-	x	-	x	x	x	x	x	x	x	x	x	x
19a	x	x	x	-	x	x	x	x	x	x	x	x	x	x
19b	x	-	x	-	x	x	x	x	x	x	x	x	x	x
20a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
20b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
21a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
21b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
22a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
22b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
23a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
23b	x	-	x	x	x	x	x	x	x	x	x	x	x	x
24a	x	-	x	-	x	x	x	x	x	x	x	x	x	x
24b	x	-	x	-	x	x	x	x	x	x	x	x	x	x
25a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
25b	x	-	x	-	x	-	x	x	x	x	x	x	x	x

Table 4-1. (Continued)

Station	1980 February N	D
14a	x	x
14b	x	x
15a	x	x
15b	x	x
16a	x	x
16b	x	x
17a	x	x
17b	x	x
18a	x	x
18b	x	x
19a	x	x
19b	x	x
20a	x	x
20b	x	x
21a	x	x
21b	x	x
22a	x	x
22b	x	x
23a	x	x
23b	x	x
24a	-	x
24b	-	x
25a	x	x
25b	x	x

Table 4-2. Summary of the cruises and collections made at each station along the transect perpendicular to shore. The "x" symbols indicate that collections were made; dashes indicate that no collections were made. The symbol "D" represents daytime collections, and the symbol "N" represents nighttime collections. All collections through September 1978 were made during daylight hours.

	1977			1978							
Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Aa	-	-	-	-	-	-	-	-	-	-	-
Ab	-	-	-	-	-	-	-	-	-	-	-
1a	x	x	x	-	x	x	x	x	x	x	-
1b	-	-	-	-	-	-	-	-	-	-	-
2a	x	x	x	-	x	x	x	x	x	x	-
2b	-	-	-	-	-	-	-	-	-	-	-
3a	x	x	x	-	x	x	x	x	x	x	-
3b	-	x	x	-	x	x	x	x	x	x	-
4a	x	x	x	-	x	x	x	x	x	-	-
4b	-	x	x	-	x	x	x	x	x	-	-
5a	x	x	x	-	x	x	x	x	x	x	-
5b	-	x	x	-	x	x	x	x	x	x	-
6a	x	x	x	-	x	x	x	x	x	x	-
6b	-	x	x	-	x	x	x	x	x	x	-
7a	x	x	x	-	x	x	x	x	x	-	-
7b	-	x	x	-	x	x	x	x	x	-	-
8a	x	x	x	-	x	x	x	x	x	x	-
8b	-	x	x	-	x	x	x	x	x	x	-
9a	x	x	x	-	x	x	x	x	x	x	-
9b	-	-	-	-	-	-	-	-	-	-	-
10a	-	-	x	-	x	x	x	x	x	x	-
10b	-	-	-	-	-	-	-	-	-	-	-
11a	-	-	x	-	x	x	x	x	x	x	-
11b	-	-	-	-	-	-	-	-	-	-	-
12a	-	-	x	-	x	x	x	x	x	x	-
12b	-	-	-	-	-	-	-	-	-	-	-
13a	-	x	x	-	x	x	x	x	x	-	-
13b	-	-	-	-	-	-	-	-	-	-	-
26a	-	-	-	-	-	-	-	-	-	-	-
26b	-	-	-	-	-	-	-	-	-	-	-

Table 4-2. Continued

Station	1978 Sept.	Oct.		Nov.		Dec.		1979 Jan.		Feb.		Mar.		Apr.		May	
		N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Aa	-	-	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
Ab	-	-	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
1a	x	-	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
1b	-	-	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
2a	x	-	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
2b	-	-	-	-	-	x	x	-	-	-	-	-	-	x	x	x	-
3a	x	x	-	-	-	x	x	-	-	-	-	-	-	x	x	x	-
3b	x	x	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
4a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5a	x	x	-	-	-	x	x	-	-	-	-	-	-	x	x	x	-
5b	x	x	-	-	-	x	x	-	-	-	-	-	-	x	x	x	-
6a	x	x	-	-	-	x	x	-	-	-	-	-	-	x	x	x	-
6b	x	x	-	-	-	x	-	-	-	-	-	-	-	x	x	x	-
7a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8a	x	-	-	-	-	x	x	-	-	-	x	-	-	x	x	x	-
8b	x	-	-	-	-	x	-	-	-	-	x	-	-	x	x	x	-
9a	x	x	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-
9b	-	-	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-
10a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
10b	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
11a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
11b	-	-	-	-	-	x	x	-	-	-	x	x	-	x	x	x	-
12a	x	x	x	-	-	x	x	-	-	-	x	x	-	x	x	x	-
12b	-	-	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-
13a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26a	-	-	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-
26b	-	-	-	-	-	x	-	-	-	-	x	x	-	x	x	x	-

Table 4-2. Continued

Station	1979 June N	June D	July N	July D	Aug. D	Sept. D	Oct. N	Oct. D	Nov. N	Nov. D	Dec. N	Dec. D	1980 Jan. N	Jan. D
Aa	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ab	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
4a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4b	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
5b	x	x	-	x	x	-	x	x	x	x	x	x	x	x
6a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6b	x	x	-	x	x	x	x	x	x	x	x	x	x	x
7a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7b	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8a	x	x	x	x	x	x	x	x	x	x	x	x	x	x
8b	x	x	x	x	x	x	x	x	x	x	x	x	x	x
9a	-	x	x	x	x	x	x	x	x	x	x	x	x	x
9b	-	x	x	x	x	x	x	x	x	x	x	x	x	x
10a	x	x	x	x	-	x	x	x	x	x	x	x	x	x
10b	x	x	x	x	-	x	x	x	x	x	x	x	x	x
11a	x	x	x	x	-	x	x	x	x	x	x	x	x	x
11b	x	x	x	x	-	x	x	x	x	x	x	x	x	x
12a	x	x	x	x	-	x	x	x	x	x	x	x	x	x
12b	x	x	x	x	-	x	x	x	x	x	x	x	x	x
13a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13b	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26a	x	x	x	x	-	x	x	x	x	x	x	x	x	x
26b	x	x	x	x	-	x	x	x	x	x	x	x	x	x

Table 4-2. Continued

Station	Feb.	
	N	D
Aa	x	x
Ab	x	x
1a	x	x
1b	x	x
2a	x	x
2b	x	x
3a	x	x
3b	x	x
4a	-	-
4b	-	-
5a	x	x
5b	x	x
6a	x	x
6b	x	x
7a	-	-
7b	-	-
8a	x	x
8b	x	x
9a	x	x
9b	x	x
10a	x	x
10b	x	x
11a	x	x
11b	x	x
12a	x	x
12b	x	x
13a	-	-
13b	-	-
26a	x	x
26b	x	x

Table 4-3. Summary of cruise dates, diel time periods, and vessels employed when stations were occupied.

Cruise	Dates of Cruise	Diel Period	Vessel
1	1 October 1977	Day	Capt. Jack
2	4-5 November 1977	Day	Teresa F.
3	2-3 December 1977	Day	Capt. Jack
4	19-20 February 1978	Day	Teresa F.
5	21-22 March 1978	Day	Marlene F.
6	14-15 April 1978	Day	Capt. Jack
7	8-9 May 1978	Day	Marlene F.
8	14-15 June 1978	Day	Teresa F.
9	15-16 July 1978	Day	Teresa F.
10	15-16 September 1978	Day	Capt. Jack
11	11 October 1978	Night	?
12	13 October 1978	Day	?
13	30 November - 2 December 1978	Night	Teresa F.
14	14-19 December 1978	Day	?
15	24-28 February 1979	Day	Marlene F.
16	12-14 March 1979	Night	Marline F.
17	5-10 April 1979	Night	Teresa F.
18	20-23 April 1979	Day	"
19	14-18 May 1979	Night	Tanya and Joe
20	6-10 June 1979	Night	"
21	21-24 June 1979	Day	"
22	5-9 July 1979	Night	"
23	19-22 July 1979	Day	"
24	22-25 August 1979	Day	Ginger B.
25	22-25 September 1979	Day	Pete and Sue
26	2-6 October 1979	Night	"
27	16-19 October 1979	Day	"
28	3-6 November 1979	Night	"
29	15-18 November 1979	Day	"
30	1-4 December 1979	Night	Pete and Sue*
31	14-19 December 1979	Day	"
32	3-6 January 1980	Night	"
33	16-20 January 1980	Day	"
34	4-11 February 1980	Night	"
35	15-20 February 1980	Day	"

*The "Pete and Sue" was modified to fish as a stern trawler commencing after November 1979.

Table 4-4. Descriptions of station locations. Depths are in fathoms.

Station	Latitude (N)	Longitude (W)	Observed Mean Depth	Assigned Arbitrary Depth
A	28°53.60'	95°20.92'	3.5	3
1	28°52.57'	95°19.56'	5	5
2	28°50.60'	95°18.82'	7	7
3	28°48.56'	95°19.59'	8.5	9
4	28°49.27'	95°18.39'	8.5	9
5	28°49.44'	95°18.10'	8.5	9
6	28°49.55'	95°17.88'	9	9
7	28°49.71'	95°17.61'	9	9
8	28°50.43'	95°16.43'	9	9
9	28°45.78'	95°15.93'	10	10
10	28°36.09'	95°12.30'	15.5	15
11	28°20.00'	95°08.70'	20	20
12	28°14.80'	95°07.80'	26	26
13	28°46.58'	95°15.99'	10	10
14	28°43.20'	95°16.12'	11.5	12
15	28°44.08'	95°14.59'	11.5	12
16	28°44.19'	95°14.41'	11.5	12
17	28°45.04'	95°12.89'	11.5	12
18	28°43.84'	95°14.96'	11.5	12
19	28°44.38'	95°14.05'	12	12
20	28°44.09'	95°15.65'	11.5	12
21	28°44.54'	95°14.81'	12	12
22	28°44.99'	95°14.04'	12	12
23	28°43.25'	95°15.00'	12	12
24	28°43.67'	95°14.18'	12	12
25	28°44.11'	95°13.35'	12	12
26	28°41.14'	95°13.41'	12.5	13

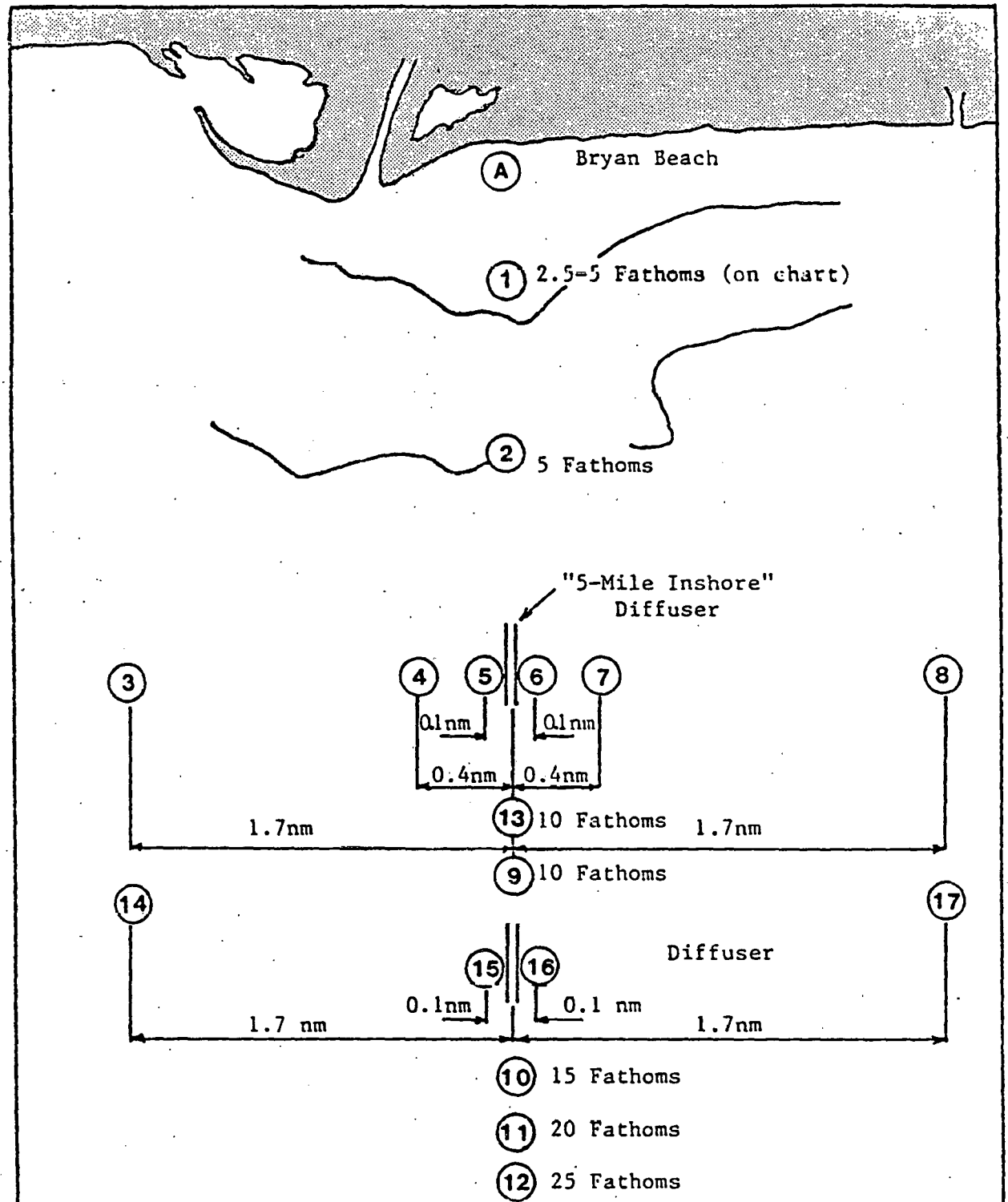

Figure 4-1a. Diagrammatic sketch of station positions (1a), including a detailed sketch of the station grid near the diffuser (1b).

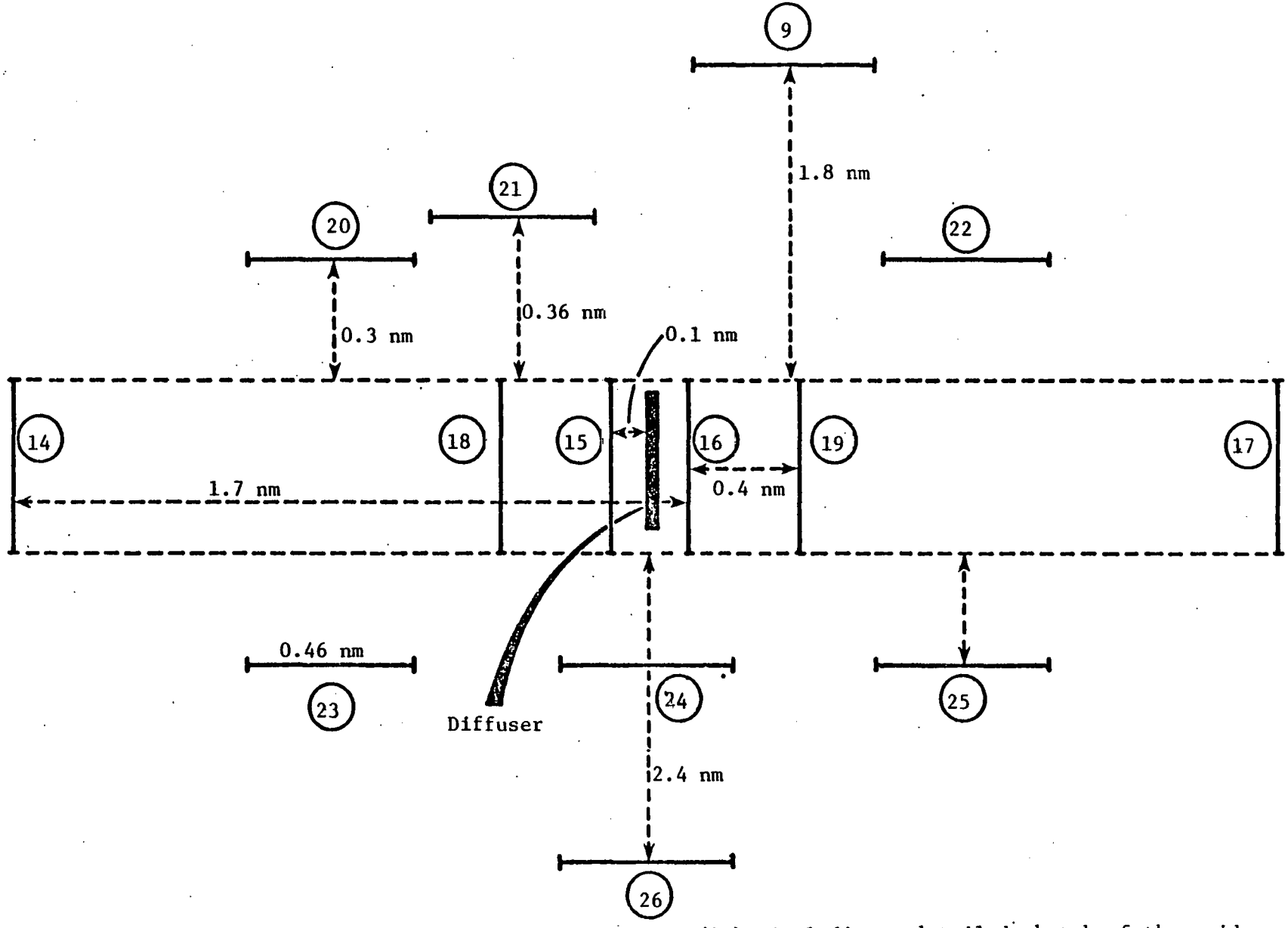

Figure 4-1b. Diagrammatic sketch of station positions (1a), including a detailed sketch of the grid near the diffuser (1b).

Each station was assigned an arbitrary depth to simplify discussion, and stations in approximately the same depth range were assigned the same arbitrary depth. For example, all stations in the diffuser area (14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, and 25) were assigned the same arbitrary depth.

4.2.2 Collections and Catch Processing Procedures

Collections were made aboard chartered shrimp trawlers using two 34-foot Hollis-Special commercial trawls equipped with tickler chains and 1 3/4 inch stretch mesh netting in the cod-end. Loran A was used initially to locate starting points for each tow, but Loran C was used commencing in December 1979. Tows were made in straight-line fashion at a speed of about 2.75 knots for ten minutes bottom time duration and covered about 0.46 nautical miles on average. Comparisons of shrimp catches in tows of 5, 10, 15, 20, 25, and 30 minutes duration (Chittenden, 1979) found little or no difference in catches and concluded that a ten minute tow was scientifically reasonable. The initial tow at a given station (tow "a") started at the loran coordinates of one end of the designated station track; the second tow at a given station (tow "b") commenced at the loran coordinates of the other end of the designated station track.

Nekton catches were processed in the field and/or in the laboratory. Commencing in December 1978, all fish and Penaeid shrimp were identified, counted,and measured in total length. Total length for fish was measured from the tip of the snout to the distal tip of the caudal fin and for Penaeid shrimp from the tip of the rostral spine to the distal tip of the uropods. Before December 1978 only certain nekton species (Table

4-5) were processed in detail because of manpower limitations. These species were identified, enumerated,and measured on the first tow at each station. Only identification and enumeration were performed normally on the second tow, but measurements were taken when manpower permitted. Fishes not initially processed were preserved and retained, being identified, measured, and incorporated into the data bank later.

Common and scientific names of fishes presented herein follow Bailey, et al. (1970) or Fischer (1978), whichever is more recent.

4.2.3 Objectives, Experimental Design, and Analytical Procedures

The objectives of the predisposal period field operations were to acquire data to:

A) permit documentation of a background picture of cross-shelf nekton communities off Freeport to describe generally their overall, diel, temporal, and spatial compositions and abundance, and

B) permit detailed description of the nekton community in the diffuser area, its temporal patterns in species compositions and total abundance, and among diffuser stations patterns in total abundance, and size and species compositions.

It was envisioned that data acquired under Objective A would create or permit: 1) ready identification of glaring background conditions that might be confused with effects of brine disposal--for example, the great reduction in nekton actually found in early summer associated with low dissolved oxygen (see Section 4.9 for details), 2)prior identification of important species that should be abundant and could be studied in detail during short intensive postdisposal studies, and 3) the existence of a geographically broad data base upon which subsequent analyses of

Table 4-5. Key to the selected important species emphasized early in this project.

Species Number	Common Name	Scientific Name
1	Brown shrimp	Penaeus aztecus
2	Pink shrimp	Penaeus duorarum
3	White shrimp	Penaeus setiferus
4	Atlantic croaker	Micropogonias undulatus
5	Sand seatrout	Cynoscion arenarius
6	Silver seatrout	Cynoscion nothus
7	Southern kingfish	Menticirrhus americanus
8	Gulf kingfish	Menticirrhus littoralis
9	Star drum	Stellifer lanceolatus
10	Sea catfish	Ariopsis felis
11	Gulf butterfish	Peprilus burti
12	Atlantic threadfin	Polydactylus octonemus
13	Longspined porgy	Stenotomus caprinus
14	Atlantic cutlassfish	Trichiurus lepturus

cause could be made if unforeseen problems became apparent after brine disposal. It was envisioned that among diffuser stations, patterns determined under Objective B would be the principal background against which the effects of brine disposal could be judged. It was envisioned, also, that between years differences and day vs night differences would exist; but they were not major objectives and the present studies were not designed to evaluate them in other than general terms.

The experimental design follows from the objectives described and was preplanned in terms of its stations vs cruises = months factorial nature. Levels of factors etc. evolved in a less planned way as the study period lengthened and as the projected diffuser location changed from 8 to 12 fathoms. This resulted in addition and deletion of many stations and eventually night and day collections. Other unplanned modifications of the experimental design ("missing data") were caused by losses in planned stations due to operational problems near the diffuser and routine trawl-program difficulties associated with bad weather, net hangups etc. Instances of "missing data" often involved stations 15 and 16 (Table 4-1) which are located closest to the brine diffuser and should show most clearly effects due to brine disposal.

Patterns of total abundance of fish and total abundance of shrimp in the diffuser area were evaluated by analysis of variance procedures using a two-way factorial experiment in a completely randomized design as calculated by the SAS program Proc GLM (Helvig and Council 1979) with LOG_e transformation of data. Factors were stations and cruises. Evaluations were made separately for night collections and for day collections within each of the following four cruise x station sets:

1) Set A, eg-- all diffuser stations, except 15 and 16, over the NIGHT CRUISES of March 1979, April 1979, May 1979, June 1979, July 1979, October 1979, November 1979, December 1979, and January 1980.

2) Set B, eg-- all diffuser stations, except 15 and 16, over the DAY CRUISES of February 1979, April 1979, August 1979, October 1979, November 1979, December 1979, January 1980, and February 1980.

3) Set C, eg-- stations 14, 15, 16 and 17 over the NIGHT CRUISES of October 1978, December 1978, March 1979, April 1979, May 1979, June 1979, and July 1979, and

4) Set D, eg-- stations 14, 15, 16, and 17 over the DAY CRUISES of July 1978, September 1978, October 1978, December 1978, February 1979, April 1979, August 1979, and October 1979.

Comparisons in analysis sets A and B excluded stations 15 and 16 because those key stations could not be occupied. Data for stations 15 and 16 were complete in analysis sets C and D, so that conclusions about among station homogeneity based upon analysis sets A and B could be broadened and linked specifically to stations 15 and 16 through analysis sets C and D. Sets were chosen to provide the most comprehensive linkage with stations 15 and 16 but minimum repetitive testing of given cruises.

Stations, cruises, and interaction were tested against the error mean square in the above preliminary ANOVA screen, because both station effects and cruise effects were assumed to be fixed (Wilk and Kempthorne 1955; Steel and Torrie 1960). Subsequent analyses of among stations differences depended upon whether interaction was significant or not. Among stations comparisons were made within cruises if interaction was significant, but among stations comparisons were made over cruises if interaction was not significant. All "among" comparisons were made at

the 5% level and used the Student-Newman-Keuls multiple comparisons test as recommended by Gill (1973) to avoid the great distortion of nominal significance levels that occur with Duncan's multiple range test. Brief statements to explain significant among station differences are given beneath each multiple range test presented.

Nekton patterns are described for each of three cross-shelf areas here defined as: 1) an inshore area that included stations A, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 13, 2) an offshore area that included stations 10, 11, and 12, and 3) the diffuser area which constituted stations 14-25 inclusive. These station groupings initially were selected in these studies to separate and contrast the diffuser area nekton, which is of greatest interest, from the nekton at stations located further inshore and further offshore. The defined inshore and offshore areas also approximated the bathymetric ranges of two major soft bottom demersal communities in the northern Gulf, a white shrimp community in the 2-12 fathom depth range and a brown shrimp community in the 12-60 fathom depth range (Hildebrand 1954; Chittenden and McEachran 1976; Chittenden and Moore 1977). These communities generally merge in a 10-20 fathom depth zone of transition (Chittenden and McEachran 1976) within which the diffuser area stations and stations 10 and 26 lie and on the edges of which stations 9 and 13 lie. A cluster analysis presented herein (Section 4.5) generally supports these previously selected station groupings, and an analysis of by-station nekton percentage compositions (Section 4.13) supports the exclusion of stations 9, 26, and 10 from the defined diffuser area.

4.3 Overall Compositions of the Penaeid Shrimp and Ichthyofauna off Freeport

A total of 37,122 Penaeid shrimp were processed in 1,098 trawl tows at stations A-26 inclusive during the period October 1977-February 1980 (Table 4-6). Penaeus setiferus (45%) and P. aztecus (51%) dominated the catch and made up about 96% of the total. Penaeus duorarum made up only 4% and evidently is not a principal Penaeid off Freeport, although large catches of this species were made about May.

A total of 651,627 fishes of 165 species and 61 families were processed in 1,098 trawl tows at stations A-26 inclusive during the period October 1977-February 1980 (Table 4-7). A complete taxonomic listing is in Appendix Table 7-1. Only ten species made up 77% of the catch, and the remaining 23% was distributed among 155 less abundant fishes. Chloroscombrus chrysurus was most abundant and made up 25% of the total, followed by Cynoscion nothus (14%) and Micropogonias undulatus (11%). These three species made up about 50% of the total catch of fishes. Other abundant species included Peprilus burti (5%) Stellifer lanceolatus (5%), Cynoscion arenarius (4%), Syacium gunteri (4%), Stenotomus caprinus (4%), Trachurus lathami (2%), and Anchoa hepsetus (2%).

Compositions and catches of Penaeid shrimp and fish vary depending upon water depth and collection locations and upon their diel activity, seasonal movements, schooling behavior, recruitment and mortality patterns, year class strength, and other factors. Subsequent sections describe in more detail the distribution and abundance of Penaeid shrimp and fishes off Freeport.

Table 4-6. Overall composition of Penaeid shrimp catches, October 1977-February 1980.

Species	Number	Percent
P. aztecus	16,876	45.46
P. setiferus	18,990	51.16
P. duorarum	1,256	3.38
	37,122	100

Table 4-7. Composition of dominant and non-dominant species of fish. All data pooled. October 1977-February 1980.

Dominant Species (10)	Number	%	Cum. %
CHLOROSCOMBRUS CHRYSURUS	161487	24.78	24.78
CYNOSCION NOTHUS	91995	14.12	38.90
MICROPOGONIAS UNDULATUS	74526	11.44	50.34
PEPRILUS BURTI	33982	5.21	55.55
STELLIFER LANCEOLATUS	33739	5.18	60.73
CYNOSCION ARENARIUS	27563	4.23	64.96
SYACIUM GUNTERI	26772	4.11	69.07
STENOTOMUS CAPRINUS	23016	3.53	72.60
TRACHURUS LATHAMI	15993	2.45	75.05
ANCHUA HEPSETUS	14046	2.16	77.21
Non-Dominant Species (155)			
ANCHOA MITCHILLI	11985	1.84	79.05
PRIONOTUS RUBIO	9700	1.49	80.54
DIPLECTRUM BIVITTATUM	9669	1.48	82.02
ARIOPSIS FELIS	9430	1.45	83.47
TRICHIURUS LEPTURUS	9357	1.44	84.90
LEIOSTOMUS XANTHURUS	8522	1.31	86.21
PORICHTHYS POROSISSIMUS	5766	0.88	87.10
LARIMUS FASCIATUS	5750	0.88	87.98
UPENEUS PARVUS	5459	0.84	88.82
HARENGULA JAGUANA	5241	0.80	89.62
PEPRILUS PARU	5210	0.80	90.42
MENTICIRRHUS AMERICANUS	4863	0.75	91.17
BREVOORTIA PATRONUS	4402	0.68	91.84
CENTROPRISTIS PHILADELPHIC	4178	0.64	92.48
SAURIDA BRASILIENSIS	4098	0.63	93.11
ETROPUS CROSSOTUS	3553	0.55	93.66
HALIEUTICHTHYS ACULEATUS	3408	0.52	94.18
SYNODUS FOETENS	3076	0.47	94.65
SPHOEROIDES PARVUS	3043	0.47	95.12
POLYDACTYLUS OCTONEMUS	2708	0.42	95.54
LEPOPHIDIUM GRAELLSI	2674	0.41	95.95
PRIACANTHUS ARENATUS	2630	0.40	96.35
ANCHOA LYOLEPIS	2071	0.32	96.67
PRIONOTUS TRIBULUS	1575	0.24	96.91
SELENE SETAPINNIS	1513	0.23	97.14
SYMPHURUS CIVITATUS	1295	0.20	97.34
CITHARICHTHYS SPILOPTERUS	1182	0.18	97.52
LUTJANUS CAMPECHANUS	1125	0.17	97.69
PRIONOTUS PARALATUS	917	0.14	97.83
LAGODON RHOMBOIDES	839	0.13	97.96
ORTHOPRISTIS CHRYSOPTERA	798	0.12	98.09
SCORPAENA CALCARATA	794	0.12	98.21
OGCOCEPHALUS SP.	740	0.11	98.32
SERRANUS ATROBRANCHUS	607	0.09	98.41
OPISTHONEMA OGLINUM	603	0.09	98.51
PRISTIPOMOIDES AQUILONARIS	574	0.09	98.59
LAGOCEPHALUS LAEVIGATUS	567	0.09	98.68
CHAETODIPTERUS FABER	493	0.08	98.76
UROPHYCIS FLORIDANUS	486	0.07	98.83
GYMNACHIRUS TEXAE	484	0.07	98.91
SYNODUS POEYI	476	0.07	98.98
BAIRDIELLA CHRYSOURA	453	0.07	99.05
ENGYOPHRYS SENTA	447	0.07	99.12

Table 4-7. (Continued).

PRIONOTUS SALMONICOLOR	445	0.07	99.19
ETRUMEUS TERES	379	0.06	99.24
GYMNOTHORAX NIGROMARGINATU	373	0.06	99.30
PRIONOTUS STEARNSI	364	0.06	99.36
BOLLMANNIA COMMUNIS	355	0.05	99.41
BAGRE MARINUS	312	0.05	99.46
CYCLOPSETTA CHITTENDENI	262	0.04	99.50
CARANX HIPPOS	233	0.04	99.54
PARALICHTHYS LETHOSTIGMA	215	0.03	99.57
SCOMBEROMORUS CAVALLA	192	0.03	99.60
RHIZOPRIONODON TERRAENOVAE	163	0.03	99.62
SERRANICULUS PUMULIO	159	0.02	99.65
LUTJANUS SYNAGRIS	153	0.02	99.67
ANCYLOPSETTA QUADROCELLATA	135	0.02	99.69
ENGRAULIS EURYSTOLE	131	0.02	99.71
PRIONOTUS OPHRYAS	119	0.02	99.73
SPHYRAENA GUACHANCHO	113	0.02	99.75
SYMPHURUS PLAGIUSA	113	0.02	99.76
BREGMACEROS ATLANTICUS	112	0.02	99.78
BALISTES CAPRISCUS	72	0.01	99.79
OPHIDION WELSHI	70	0.01	99.80
HEMICARANX AMBLYRHYNCHUS	65	0.01	99.81
MENTICIRRHUS LITTORALIS	63	0.01	99.82
SARDINELLA AURITA	61	0.01	99.83
ASTROSCOPUS Y-GRAECUM	57	0.01	99.84
BROTULA BARBATA	55	0.01	99.85
BELLATOR MILITARIS	49	0.01	99.86
SCOMBEROMORUS MACULATUS	47	0.01	99.86
UROPHYCIS CIRRATUS	45	0.01	99.87
DECAPTERUS PUNCTATUS	43	0.01	99.88
SPHYRNA TIBURO	42	0.01	99.88
CARANX CRYSOS	40	0.01	99.89
ACHIRUS LINEATUS	40	0.01	99.90
RAJA TEXANA	35	0.01	99.90
PAREQUES UMBROSUS	35	0.01	99.91
STEPHANOLEPIS HISPIDUS	33	0.01	99.91
POMATOMUS SALTATOR	31	0.00	99.92
PARALICHTHYS ALBIGUTTA	28	0.00	99.92
DASYATIS SABINA	27	0.00	99.93
SYMPHURUS DIOMEDIANUS	25	0.00	99.93
ARCHOSARGUS PROBATOCEPHALU	25	0.00	99.93
DOROSOMA PETENENSE	25	0.00	99.94
PRIONOTUS SCITULUS	24	0.00	99.94
EUCINOSTOMUS ARGENTEUS	23	0.00	99.94
TRACHINOTUS CAROLINUS	20	0.00	99.95
MULLUS AURATUS	19	0.00	99.95
SERRANUS SUBLIGARIUS	19	0.00	99.95
CHILOMYCTERUS SCHOEPFI	18	0.00	99.96
CAULOLATILUS INTERMEDIUS	16	0.00	99.96
ANTENNARIUS RADIOSUS	16	0.00	99.96
EUCINOSTOMUS GULA	14	0.00	99.96
SELENE VOMER	13	0.00	99.96
SYNGNATHUS LOUISIANAE	13	0.00	99.97
SPHOEROIDES DORSALIS	12	0.00	99.97
ANCYLOPSETTA DILECTA	11	0.00	99.97
POGONIAS CROMIS	9	0.00	99.97
PRIONOTUS ROSEUS	9	0.00	99.97
SCOMBER JAPONICUS	8	0.00	99.97
MENIDIA BERYLLINA	8	0.00	99.98
SELAR CRUMENOPHTHALMUS	8	0.00	99.98
RYPTICUS MACULATUS	8	0.00	99.98
ECHENEIS NAUCRATES	8	0.00	99.98
OPHIDION GRAYI	7	0.00	99.98
RHINOPTERA BONASUS	6	0.00	99.98
MUGIL CEPHALUS	5	0.00	99.98

Table 4-7. (Continued).

MUSTELUS CANIS	5	0.00	99.98
EUCINOSTOMUS MELANOPTERUS	4	0.00	99.98
DASYATIS AMERICANUS	4	0.00	99.98
GOBIONELLUS HASTATUS	4	0.00	99.98
HIPPOCAMPUS ERECTUS	4	0.00	99.99
CARCHARHINUS BREVIPINNA	4	0.00	99.99
SYMPHURUS UROSPILUS	4	0.00	99.99
OPHICHTHUS GOMESI	4	0.00	99.99
EPINEPHELUS NIVEATUS	4	0.00	99.99
STEPHANOLEPIS SETIFER	4	0.00	99.99
OLIGOPLITES SAURUS	4	0.00	99.99
DASYATIS SAYI	4	0.00	99.99
OPHIDION HOLBROOKI	3	0.00	99.99
RACHYCENTRON CANADUM	3	0.00	99.99
ECHIOPSIS PUNCTIFER	3	0.00	99.99
SCIAENOPS OCELLATA	3	0.00	99.99
HAEMULON AUROLINEATUM	3	0.00	99.99
HOPLUNNIS MACRURUS	3	0.00	99.99
HEMIRHAMPHUS BRASILIENSIS	3	0.00	99.99
HOPLUNNIS TENUIS	3	0.00	99.99
CITHARICHTHYS MACROPS	3	0.00	99.99
OPISTOGNATHUS SP.	2	0.00	99.99
SPHYRNA LEWINI	2	0.00	99.99
SYACIUM PAPILLOSUM	2	0.00	99.99
TRINECTES MACULATUS	2	0.00	99.99
CARCHARHINUS ACRONOTUS	2	0.00	99.99
LONCHOPISTHUS LINDNERI	2	0.00	100.00
HILDEBRANDIA FLAVA	2	0.00	100.00
MEMBRAS MARTINICA	1	0.00	100.00
ALOSA CHRYSOCHLORIS	1	0.00	100.00
SPHOEROIDES SPENGLERI	1	0.00	100.00
TRICHOPSETTA VENTRALIS	1	0.00	100.00
GOBIESOX STRUMOSUS	1	0.00	100.00
CONODON NOBILIS	1	0.00	100.00
PHRYNELOX SCABER	1	0.00	100.00
CARCHARHINUS PLUMBEUS	1	0.00	100.00
CARCHARHINUS POROSUS	1	0.00	100.00
PAREXCOETUS BRACHYPTERUS	1	0.00	100.00
CYNOSCION NEBULOSUS	1	0.00	100.00
ACANTHOSTRACION QUADRICORN	1	0.00	100.00
ALUTERUS SCHOEPFI	1	0.00	100.00
TRACHINOCEPHALUS MYOPS	1	0.00	100.00
RHOMBOPLITES AURORUBENS	1	0.00	100.00
CANTHERHINES PULLUS	1	0.00	100.00
PARALICHTHYS SQUAMILENTUS	1	0.00	100.00
DACTYLOPTERUS VOLITANS	1	0.00	100.00
TOTAL	651627		

4.4 Diel Variation in Compositions of the Penaeid Shrimp and Ichthyofauna off Freeport

Compositions of the ichthyofauna and shrimp catches vary between day and night. This phenomenon is recognized by the shrimp industry because, for example, trawling for P. aztecus and P. duorarum is usually done at night when they are most active (Moffett 1970). This phenomenon has also been suggested for fishes, but Gulf demersal fishes rarely--if ever--have been collected around the clock to properly describe diel periodicity. The present section describes pooled compositions of the Penaeid shrimp and ichthyofauna at night (Table 4-8, 4-9) and during the day (Tables 4-8, 4-10) for the period December 1978-February 1980 when cruises usually were made during both day and night. However, these data do not permit day-night comparisons in the same 24-hour period.

A total of 20,304 Penaeid shrimp were counted during night cruises in the period December 1978-February 1980, and 9,523 were counted during day cruises (Table 4-8). Penaeus aztecus made up 57% of the catch at night but only 32% of the catch during the day. In contrast, P. setiferus made up 67% of the catch in the day but only 37% at night. The pink shrimp, P. duorarum made up 6% at night and only 0.4% during the day.

A total of 210,299 fishes of 143 species were counted during the night cruises in the period December 1978-February 1980 (Table 4-9). Ten abundant species made up 79% of the catch at night while 133 less abundant species made up the remaining 21%. Cynoscion nothus (24%) dominated the ichthyofauna at night, closely followed by Micropogonias undulatus (15%). Other abundant species included Stenotomus caprinus (8%), Syacium gunteri (8%), Stellifer lanceolatus (7%), Cynoscion

Table 4-8. Composition of the shrimp catches during the day and during the night, December 1978 - February 1980.

	Night		Day	
Species	Number	Percent	Number	Percent
P. aztecus	11,538	56.8	3,078	32.3
P. duorarum	1,167	5.8	39	0.4
P. setiferus	7,599	37.4	6,406	67.3
Total	20,304	100	9,523	100

Table 4-9. Composition of dominant and non-dominant species of fish. Night cruises. December 1978-February 1980.

Dominant Species (10)	Number	%	Cum. %
CYNOSCION NOTHUS	49761	23.66	23.66
MICROPOGONIAS UNDULATUS	32200	15.31	38.97
STENOTOMUS CAPRINUS	16481	7.84	46.81
SYACIUM GUNTERI	15859	7.54	54.35
STELLIFER LANCEOLATUS	14709	6.99	61.35
CYNOSCION ARENARIUS	14510	6.90	68.25
PRIONOTUS RUBIO	6710	3.19	71.44
DIPLECTRUM BIVITTATUM	6701	3.19	74.62
PORICHTHYS POROSISSIMUS	4563	2.17	76.79
ARIOPSIS FELIS	4365	2.08	78.87
Non-Dominant Species (133)			
CHLOROSCOMBRUS CHRYSURUS	2931	1.39	80.26
HALIEUTICHTHYS ACULEATUS	2928	1.39	81.65
CENTROPRISTIS PHILADELPHIC	2924	1.39	83.04
MENTICIRRHUS AMERICANUS	2800	1.33	84.38
UPENEUS PARVUS	2674	1.27	85.65
LEPOPHIDIUM GRAELLSI	2586	1.23	86.88
ETROPUS CROSSOTUS	2216	1.05	87.93
SPHOEROIDES PARVUS	1884	0.90	88.83
LARIMUS FASCIATUS	1735	0.83	89.65
ANCHOA MITCHILLI	1698	0.81	90.46
PRIACANTHUS ARENATUS	1417	0.67	91.13
PEPRILUS BURTI	1303	0.62	91.75
SYNODUS FOETENS	1104	0.52	92.28
LEIOSTOMUS XANTHURUS	1045	0.50	92.77
PRIONOTUS TRIBULUS	1031	0.49	93.26
SAURIDA BRASILIENSIS	982	0.47	93.73
SYMPHURUS CIVITATUS	979	0.47	94.20
BREVOORTIA PATRONUS	936	0.45	94.64
CITHARICHTHYS SPILOPTERUS	769	0.37	95.01
SCORPAENA CALCARATA	727	0.35	95.35
PRIONOTUS PARALATUS	690	0.33	95.68
TRICHIURUS LEPTURUS	625	0.30	95.98
OGCOCEPHALUS SP.	522	0.25	96.23
POLYDACTYLUS OCTONEMUS	510	0.24	96.47
LUTJANUS CAMPECHANUS	423	0.20	96.67
ORTHOPRISTIS CHRYSOPTERA	409	0.19	96.87
SERRANUS ATROBRANCHUS	385	0.18	97.05
GYMNOTHORAX NIGROMARGINATU	371	0.18	97.22
GYMNACHIRUS TEXAE	369	0.18	97.40
PRIONOTUS SALMONICOLOR	368	0.17	97.58
ENGYOPHRYS SENTA	362	0.17	97.75
BOLLMANNIA COMMUNIS	339	0.16	97.91
PEPRILUS PARU	335	0.16	98.07
PRISTIPOMOIDES AQUILONARIS	333	0.16	98.23
LAGODON RHOMBOIDES	331	0.16	98.38
UROPHYCIS FLORIDANUS	315	0.15	98.53
SYNODUS POEYI	264	0.13	98.66
BAIRDIELLA CHRYSOURA	217	0.10	98.76
CYCLOPSETTA CHITTENDENI	160	0.08	98.84
CHAETODIPTERUS FABER	158	0.08	98.91
SELENE SETAPINNIS	141	0.07	98.98
LAGOCEPHALUS LAEVIGATUS	136	0.06	99.04
SERRANICULUS PUMULIO	136	0.06	99.11

Table 4-9. (Continued).

ANCHOA LYOLEPIS	128	0.06	99.17
TRACHURUS LATHAMI	127	0.06	99.23
PRIONOTUS STEARNSI	124	0.06	99.29
ANCHOA HEPSETUS	113	0.05	99.34
BREGMACEROS ATLANTICUS	112	0.05	99.40
PARALICHTHYS LETHOSTIGMA	91	0.04	99.44
SYMPHURUS PLAGIUSA	90	0.04	99.48
OPISTHONEMA OGLINUM	73	0.03	99.52
PRIONOTUS OPHRYAS	70	0.03	99.55
BAGRE MARINUS	65	0.03	99.58
MENTICIRRHUS LITTORALIS	57	0.03	99.61
ANCYLOPSETTA QUADROCELLATA	57	0.03	99.64
BROTULA BARBATA	45	0.02	99.66
UROPHYCIS CIRRATUS	43	0.02	99.68
BELLATOR MILITARIS	42	0.02	99.70
RHIZOPRIONODON TERRAENOVAE	37	0.02	99.72
ASTROSCOPUS Y-GRAECUM	34	0.02	99.73
ACHIRUS LINEATUS	32	0.02	99.75
OPHIDION WELSHI	29	0.01	99.76
RAJA TEXANA	24	0.01	99.77
SYMPHURUS DIOMEDIANUS	23	0.01	99.78
BALISTES CAPRISCUS	23	0.01	99.79
STEPHANOLEPIS HISPIDUS	23	0.01	99.80
PRIONOTUS SCITULUS	22	0.01	99.81
PAREQUES UMBROSUS	20	0.01	99.82
DASYATIS SABINA	19	0.01	99.83
SERRANUS SUBLIGARIUS	18	0.01	99.84
MULLUS AURATUS	17	0.01	99.85
ARCHOSARGUS PROBATOCEPHALU	16	0.01	99.86
ANTENNARIUS RADIOSUS	15	0.01	99.86
CAULOLATILUS INTERMEDIUS	13	0.01	99.87
EUCINOSTOMUS ARGENTEUS	13	0.01	99.88
CHILOMYCTERUS SCHOEPFI	13	0.01	99.88
ETRUMEUS TERES	12	0.01	99.89
DOROSOMA PETENENSE	12	0.01	99.89
SPHOEROIDES DORSALIS	10	0.00	99.90
PARALICHTHYS ALBIGUTTA	10	0.00	99.90
DECAPTERUS PUNCTATUS	10	0.00	99.91
SCOMBEROMORUS MACULATUS	10	0.00	99.91
LUTJANUS SYNAGRIS	10	0.00	99.92
CARANX HIPPOS	9	0.00	99.92
ENGRAULIS EURYSTOLE	8	0.00	99.93
RYPTICUS MACULATUS	8	0.00	99.93
SPHYRNA TIBURO	8	0.00	99.93
ANCYLOPSETTA DILECTA	8	0.00	99.94
SYNGNATHUS LOUISIANAE	7	0.00	99.94
HARENGULA JAGUANA	6	0.00	99.94
SPHYRAENA GUACHANCHO	5	0.00	99.95
OPHIDION GRAYI	5	0.00	99.95
SARDINELLA AURITA	5	0.00	99.95
TRACHINOTUS CAROLINUS	4	0.00	99.95
HIPPOCAMPUS ERECTUS	4	0.00	99.95
POGONIAS CROMIS	4	0.00	99.96
CARCHARHINUS BREVIPINNA	4	0.00	99.96
SCOMBER JAPONICUS	4	0.00	99.96
SYMPHURUS UROSPILUS	4	0.00	99.96
HEMICARANX AMBLYRHYNCHUS	4	0.00	99.96
OLIGOPLITES SAURUS	4	0.00	99.97
HAEMULON AUROLINEATUM	3	0.00	99.97
ECHIOPSIS PUNCTIFER	3	0.00	99.97
EUCINOSTOMUS GULA	3	0.00	99.97
GOBIONELLUS HASTATUS	3	0.00	99.97
POMATOMUS SALTATOR	3	0.00	99.97
SELENE VOMER	3	0.00	99.97
MUGIL CEPHALUS	3	0.00	99.98

Table 4-9. (Continued).

OPHIDION HOLBROOKI	3	0.00	99.98
EPINEPHELUS NIVEATUS	3	0.00	99.98
CITHARICHTHYS MACROPS	3	0.00	99.98
PRIONOTUS ROSEUS	3	0.00	99.98
HOPLUNNIS MACRURUS	3	0.00	99.98
HOPLUNNIS TENUIS	3	0.00	99.98
DASYATIS AMERICANUS	2	0.00	99.99
OPISTOGNATHUS SP.	2	0.00	99.99
EUCINOSTOMUS MELANOPTERUS	2	0.00	99.99
TRINECTES MACULATUS	2	0.00	99.99
ECHENEIS NAUCRATES	2	0.00	99.99
DASYATIS SAYI	2	0.00	99.99
LONCHOPISTHUS LINDNERI	2	0.00	99.99
STEPHANOLEPIS SETIFER	2	0.00	99.99
HILDEBRANDIA FLAVA	2	0.00	99.99
TRICHOPSETTA VENTRALIS	1	0.00	99.99
RACHYCENTRON CANADUM	1	0.00	99.99
SPHYRNA LEWINI	1	0.00	99.99
SCIAENOPS OCELLATA	1	0.00	100.00
DACTYLOPTERUS VOLITANS	1	0.00	100.00
CARANX CRYSOS	1	0.00	100.00
MUSTELUS CANIS	1	0.00	100.00
PARALICHTHYS SQUAMILENTUS	1	0.00	100.00
ACANTHOSTRACION QUADRICORN	1	0.00	100.00
TOTAL	210299		

Table 4-10. Composition of dominant and non-dominant species of fish. Day cruises. December 1978-February 1980.

Dominant Species (8)	Number	%	Cum. %
CHLOROSCOMBRUS CHRYSURUS	140925	41.60	41.60
MICROPOGONIAS UNDULATUS	35071	10.35	51.95
CYNOSCION NOTHUS	28919	8.54	60.49
PEPRILUS BURTI	25040	7.39	67.88
STELLIFER LANCEOLATUS	17296	5.11	72.99
CYNOSCION ARENARIUS	11020	3.25	76.24
SYACIUM GUNTERI	7460	2.20	78.44
TRICHIURUS LEPTURUS	7053	2.08	80.53
Non-Dominant Species (126)			
LEIOSTOMUS XANTHURUS	6439	1.90	82.43
TRACHURUS LATHAMI	5337	1.58	84.00
ARIOPSIS FELIS	4848	1.43	85.43
STENOTOMUS CAPRINUS	4305	1.27	86.70
ANCHOA HEPSETUS	3989	1.18	87.88
LARIMUS FASCIATUS	3658	1.08	88.96
ANCHOA MITCHILLI	3639	1.07	90.04
BREVOORTIA PATRONUS	3403	1.00	91.04
SAURIDA BRASILIENSIS	2848	0.84	91.88
UPENEUS PARVUS	2680	0.79	92.67
PRIONOTUS RUBIO	2655	0.78	93.46
MENTICIRRHUS AMERICANUS	1995	0.59	94.05
HARENGULA JAGUANA	1863	0.55	94.60
DIPLECTRUM BIVITTATUM	1617	0.48	95.07
POLYDACTYLUS OCTONEMUS	1509	0.45	95.52
SYNODUS FOETENS	1490	0.44	95.96
PEPRILUS PARU	1330	0.39	96.35
PRIACANTHUS ARENATUS	1209	0.36	96.71
SELENE SETAPINNIS	1179	0.35	97.06
ETROPUS CROSSOTUS	959	0.28	97.34
CENTROPRISTIS PHILADELPHIC	923	0.27	97.61
ANCHOA LYOLEPIS	822	0.24	97.85
SPHOEROIDES PARVUS	590	0.17	98.03
PORICHTHYS POROSISSIMUS	569	0.17	98.20
PRIONOTUS TRIBULUS	465	0.14	98.33
LAGOCEPHALUS LAEVIGATUS	409	0.12	98.45
LAGODON RHOMBOIDES	406	0.12	98.57
ORTHOPRISTIS CHRYSOPTERA	349	0.10	98.68
OPISTHONEMA OGLINUM	301	0.09	98.77
HALIEUTICHTHYS ACULEATUS	296	0.09	98.85
LUTJANUS CAMPECHANUS	286	0.08	98.94
CHAETODIPTERUS FABER	253	0.07	99.01
CITHARICHTHYS SPILOPTERUS	238	0.07	99.08
SYMPHURUS CIVITATUS	223	0.07	99.15
CARANX HIPPOS	197	0.06	99.21
PRIONOTUS STEARNSI	194	0.06	99.26
PRISTIPOMOIDES AQUILONARIS	190	0.06	99.32
BAGRE MARINUS	183	0.05	99.37
SERRANUS ATROBRANCHUS	137	0.04	99.41
BAIRDIELLA CHRYSOURA	135	0.04	99.45
PRIONOTUS PARALATUS	129	0.04	99.49
OGCOCEPHALUS SP.	128	0.04	99.53
SYNODUS POEYI	124	0.04	99.57
UROPHYCIS FLORIDANUS	122	0.04	99.60
RHIZOPRIONODON TERRAENOVAE	113	0.03	99.64

Table 4-10. (Continued).

SCOMBEROMORUS CAVALLA	102	0.03	99.67
PARALICHTHYS LETHOSTIGMA	101	0.03	99.70
SPHYRAENA GUACHANCHO	99	0.03	99.72
ETRUMEUS TERES	86	0.03	99.75
CYCLOPSETTA CHITTENDENI	67	0.02	99.77
ENGRAULIS EURYSTOLE	55	0.02	99.79
ENGYOPHRYS SENTA	55	0.02	99.80
ANCYLOPSETTA QUADROCELLATA	51	0.02	99.82
PRIONOTUS SALMONICOLOR	47	0.01	99.83
GYMNACHIRUS TEXAE	44	0.01	99.84
LEPOPHIDIUM GRAELLSI	42	0.01	99.86
SCOMBEROMORUS MACULATUS	34	0.01	99.87
SARDINELLA AURITA	32	0.01	99.88
BALISTES CAPRISCUS	31	0.01	99.88
DECAPTERUS PUNCTATUS	31	0.01	99.89
CARANX CRYSOS	28	0.01	99.90
HEMICARANX AMBLYRHYNCHUS	27	0.01	99.91
ASTROSCOPUS Y-GRAECUM	22	0.01	99.92
SPHYRNA TIBURO	18	0.01	99.92
PARALICHTHYS ALBIGUTTA	17	0.01	99.93
TRACHINOTUS CAROLINUS	16	0.00	99.93
SYMPHURUS PLAGIUSA	15	0.00	99.94
BOLLMANNIA COMMUNIS	14	0.00	99.94
OPHIDION WELSHI	13	0.00	99.94
SELENE VOMER	10	0.00	99.95
LUTJANUS SYNAGRIS	10	0.00	99.95
SELAR CRUMENOPHTHALMUS	8	0.00	99.95
SCORPAENA CALCARATA	8	0.00	99.95
RAJA TEXANA	8	0.00	99.96
DOROSOMA PETENENSE	7	0.00	99.96
BROTULA BARBATA	7	0.00	99.96
PRIONOTUS OPHRYAS	7	0.00	99.96
STEPHANOLEPIS HISPIDUS	7	0.00	99.97
DASYATIS SABINA	7	0.00	99.97
ARCHOSARGUS PROBATOCEPHALU	6	0.00	99.97
SERRANICULUS PUMULIO	6	0.00	99.97
ACHIRUS LINEATUS	6	0.00	99.97
EUCINOSTOMUS GULA	5	0.00	99.97
EUCINOSTOMUS ARGENTEUS	5	0.00	99.98
POGONIAS CROMIS	5	0.00	99.98
ECHENEIS NAUCRATES	5	0.00	99.98
MUSTELUS CANIS	4	0.00	99.98
SYNGNATHUS LOUISIANAE	4	0.00	99.98
POMATOMUS SALTATOR	3	0.00	99.98
CAULOLATILUS INTERMEDIUS	3	0.00	99.98
ELOPS SAURUS	3	0.00	99.98
RHINOPTERA BONASUS	3	0.00	99.98
MENTICIRRHUS LITTORALIS	3	0.00	99.99
CARCHARHINUS ACRONOTUS	2	0.00	99.99
PAREQUES UMBROSUS	2	0.00	99.99
DASYATIS SAYI	2	0.00	99.99
CHILOMYCTERUS SCHOEPFI	2	0.00	99.99
OPHIDION GRAYI	2	0.00	99.99
RACHYCENTRON CANADUM	2	0.00	99.99
GYMNOTHORAX NIGROMARGINATU	2	0.00	99.99
MULLUS AURATUS	2	0.00	99.99
STEPHANOLEPIS SETIFER	2	0.00	99.99
SCIAENOPS OCELLATA	2	0.00	99.99
BELLATOR MILITARIS	2	0.00	99.99
PRIONOTUS SCITULUS	2	0.00	99.99
PRIONOTUS ROSEUS	2	0.00	99.99
SYMPHURUS DIOMEDIANUS	2	0.00	99.99
PHRYNELOX SCABER	1	0.00	99.99
SPHYRNA LEWINI	1	0.00	99.99
DASYATIS AMERICANUS	1	0.00	99.99

Table 4-10. (Continued).

MEMBRAS MARTINICA	1	0.00	99.99
ANCYLOPSETTA DILECTA	1	0.00	99.99
CYNOSCION NEBULOSUS	1	0.00	100.00
UROPHYCIS CIRRATUS	1	0.00	100.00
GOBIESOX STRUMOSUS	1	0.00	100.00
SERRANUS SUBLIGARIUS	1	0.00	100.00
ALUTERUS SCHOEPFI	1	0.00	100.00
CARCHARHINUS POROSUS	1	0.00	100.00
OPHICHTHUS GOMESI	1	0.00	100.00
CANTHERHINES PULLUS	1	0.00	100.00
ALOSA CHRYSOCHLORIS	1	0.00	100.00
RHOMBOPLITES AURORUBENS	1	0.00	100.00
CARCHARHINUS PLUMBEUS	1	0.00	100.00
SCOMBER JAPONICUS	1	0.00	100.00
EPINEPHELUS NIVEATUS	1	0.00	100.00
TOTAL	333752		

arenarius (7%), Diplectrum bivittatum (3%), Prionotus rubio (3%), Ariopsis felis (2%), and Porichthys porosissimus (2%).

A total of 338,752 fishes of 134 species were counted during day cruises in the period December 1978-February 1980 (Table 4-10). Eight abundant species made up 81% of the catch during the day while 126 less abundant species made up the remaining 19%. Chloroscombrus chrysurus (42%) dominated the catch during the day. Other abundant species included Micropogonias undulatus (10%), Cynoscion nothus (9%), Peprilus burti (7%), Stellifer lanceolatus (5%), Cynoscion arenarius (3%), Syacium gunteri (2%), and Trichiurius lepturus (2%).

4.4.1 Section Discussion

Shrimp catches have shown the generally recognized diel pattern (Moffett, 1970) that catches of P. aztecus and P. duorarum are greatest at night and catches of P. setiferus are greatest in the day. However, this pattern is not absolute. Many P. aztecus were captured during the day in waters shallower than 10 fathoms in the period June-December, so that this species is active during the day as it migrates offshore. In contrast, virtually none were captured during the day in waters of 15-25 fathoms (Stations 10, 11, and 12), so that this species must be active only at night in offshore waters. Apparently P. aztecus undergoes a transition from a partly diurnal to a nocturnal pattern in the 10-15 fathom bathymetric range. Stormy weather also may affect shrimp periodicity, possibly by modifying bottom turbidity. Chittenden (1979) described a complete reversal in the normal patterns of shrimp periodicity associated with stormy weather; greatest numbers of P. aztecus were

captured in the day but greatest numbers of P. setiferus were captured at night.

Fish catches also showed distinct day-night differences, although round-the-clock comparative studies are needed to properly establish the apparent differences. Such studies originally were proposed, but were deleted. Cynoscion nothus catches and percent compositions doubled at night, and several other species also were much more prominent then including Stenotomus caprinus, Prionotus rubio, and Porichthys porosissimus. The nocturnal behavior of P. porosissimus has been described previously (Lane, 1967), and DeVries (1979) noted day-night variation in size composition of Cynoscion nothus although he did not mention differences in catch. Several fishes were far more prominent in the day notably including pelagic forms such as Chloroscombrus chrysurus, Peprilus burti, and Trachurus lathami. Trichiurus lepturus was also more important in day catches than at night as would be expected from Dawson's (1967) observation that this species rises off the bottom at night.

4.5 Community Delineation and Compositions of the Penaeid Shrimp Fauna and Ichthyofauna by Area off Freeport

Overall compositions of the Penaeid shrimp fauna and ichthyofauna presented previously to set a general background are described in the present section for the defined inshore area and for the defined offshore area after delineation of broad station sets via cluster analysis. Compositions in the diffuser area are presented in Section 4.11, and Appendix Tables 7-2, 7-3, and 7-4 summarize ichthyofauna at stations 9, 10, and 26, respectively.

4.5.1 Delineation of Nekton Communities off Freeport

Three principal station sets existed off Freeport in the 2-25 fathom bathymetric range during the period October 1977-February 1980 as delineated by a cluster analysis using the Bray-Curtis coefficient of similarity and flexible sorting (Clifford and Stephenson 1975). These station sets included (Figure 4-2): 1) an inshore set occupying the 3-10 fathom depth range and made up of stations A, 1-8 inclusive, and 13, 2) an offshore set occupying the 20-25 fathom bathymetric range and made up of stations 11 and 12, and 3) an intermediate set occupying the 10-15 fathom bathymetric range and made up of stations 9, 10, 26, and 14-25 inclusive.

Within the inshore set several slightly dissimilar sets existed. Stations A and 1, which were very similar, occupy the shallowest depths sampled (3-5 fathoms). The "inshore diffuser" stations 3, 5, 6,and 8 were very similar, occupy the 9 fathom depth range, and were slightly dissimilar to station 2 which is in 7 fathoms. Stations 4, 7, and 13 were very similar and were occupied for only a short period, being discontinued after June 1978. Ignoring stations 4, 7, and 13, the pattern of these slightly dissimilar sets, in general, suggests gradual change with increasing depth.

Within the intermediate set, several interesting, slightly dissimilar sets existed. The diffuser stations 14, 15, 16, 17, 18, and 19 were very slightly dissimilar from stations 20, 21, 22, 23, 24, and 25. This interesting type of pattern was noted in the Intensive Postdisposal Report in that abundance of Peprilus burti during two cruises was much greater at the stations oriented perpendicular to the shoreline (eg--14,

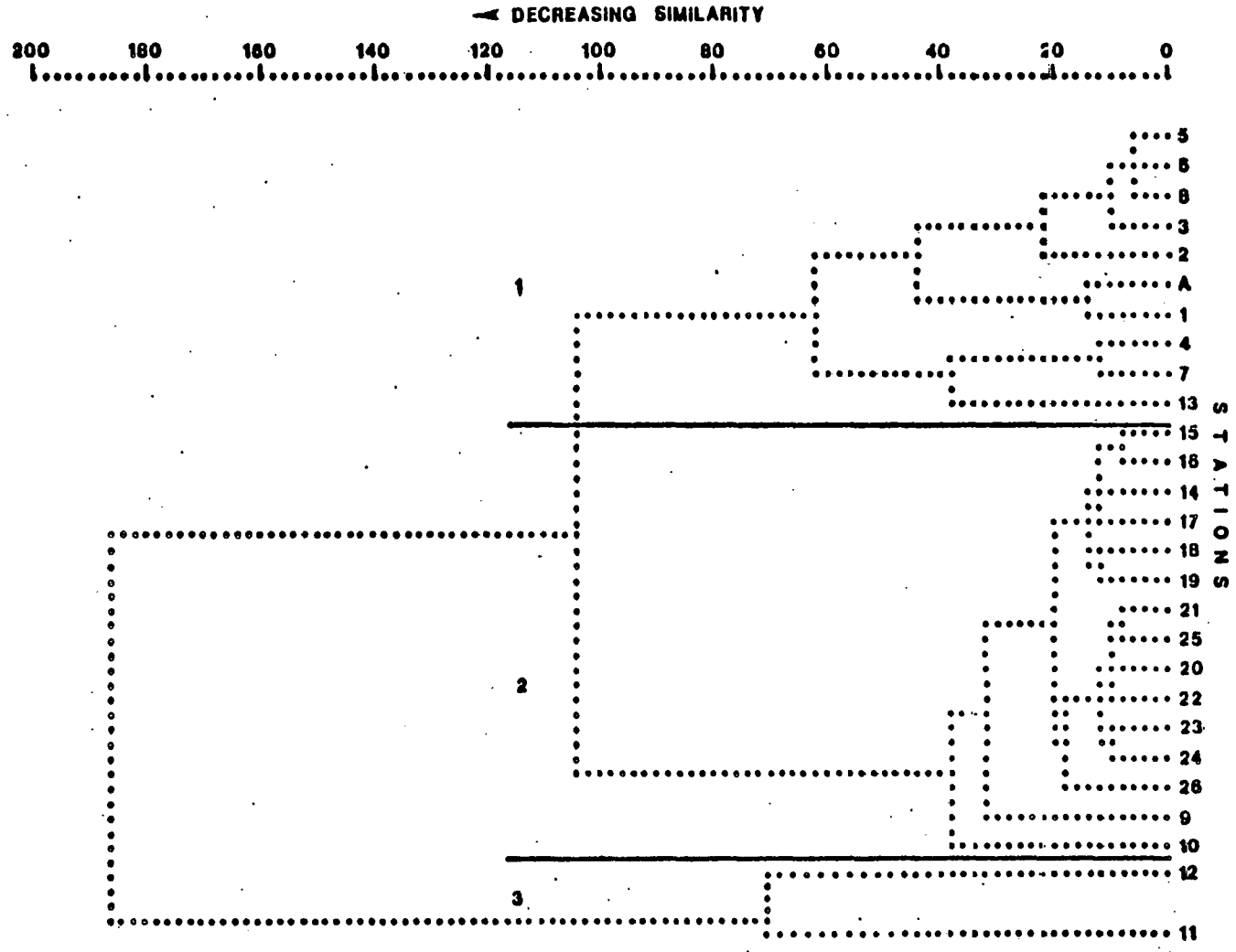

Figure 4-2. Cluster analysis of nekton data off Freeport to compare stations and delineate groupings, October 1977 - February 1980.

15, 16, 17, 18, and 19) than at stations oriented parallel to the shoreline (eg--20, 21, 22, 23, 24, 25). The reason for the pattern is not clear, although it was suggested that different orientation to prevailing currents might be involved. Finally, stations 9 and, especially, 10 were most dissimilar from other stations in this set which is not too surprising because station 9 is on the very inshore edge of this set and is in shallower water while station 10 is in deeper water than other stations.

4.5.2 Faunal Compositions in the Inshore Area

A total of 22,439 Penaeid shrimp and 337,165 fishes of 121 species were processed in 476 trawl tows at stations A-9 inclusive during the period October 1977-February 1980 (Tables 4-11, 4-12).

Penaeus setiferus dominated the shrimp catch in the inshore area and made up 78% of the total. Penaeus aztecus (21%) was much less important, and P. duorarum only made up 2% of the catch.

Only eight species made up 81% of the ichthyofauna in the inshore area while 113 less abundant species made up the remaining 19%. Chloroscombrus chrysurus (24%) and Micropogonias undulatus (21%) dominated the inshore ichthyofauna, followed by Cynoscion nothus (12%) and Stellifer lanceolatus (10%). Other abundant species included Cynoscion arenarius (4%), Anchoa mitchilli (4%), Peprilus burti (3%), and Ariopsis felis (2%).

4.5.3 Faunal Compositions in the Offshore Area

A total of 2,505 Penaeid shrimp and 61,210 fishes of 113 species were processed in the catch from 161 trawl tows at stations 10, 11, and 12 during the period October 1977-February 1980 (Tables 4-11, 4-13).

Table 4-11. Composition of Penaeid shrimp catches by area, October 1977 - February 1980.

Area	Penaeus aztecus	Penaeus duorarum	Penaeus setiferus	Species pooled
Inshore				
Number	4,628	371	17,440	22,439
Percent	20.6	1.7	77.7	59.0
Offshore				
Number	2,301	193	11	2,505
Percent	91.9	7.7	0.4	6.6
Diffuser				
Number	8,892	644	1,488	11,024
Percent	80.7	5.8	13.5	29.0

Table 4-12. Composition of dominant and non-dominant species of fish. Inshore area. October 1977-February 1980.

Dominant Species (8)	Number	%	Cum. %
CHLOROSCOMBRUS CHRYSURUS	81315	24.12	24.12
MICROPOGONIAS UNDULATUS	70715	20.97	45.09
CYNOSCION NOTHUS	41584	12.33	57.42
STELLIFER LANCEOLATUS	33739	10.01	67.43
CYNOSCION ARENARIUS	14558	4.32	71.75
ANCHOA MITCHILLI	11803	3.50	75.25
PEPRILUS BURTI	9780	2.90	78.15
ARIOPSIS FELIS	8298	2.46	80.61
Non-Dominant Species (113)			
TRICHIURUS LEPTURUS	6484	1.92	82.53
TRACHURUS LATHAMI	6305	1.87	84.40
ANCHOA HEPSETUS	6029	1.79	86.19
LARIMUS FASCIATUS	5370	1.59	87.78
LEIOSTOMUS XANTHURUS	5261	1.56	89.35
MENTICIRRHUS AMERICANUS	4633	1.37	90.72
PEPRILUS PARU	4519	1.34	92.06
BREVOORTIA PATRONUS	4359	1.29	93.35
HARENGULA JAGUANA	3442	1.02	94.37
POLYDACTYLUS OCTONEMUS	2073	0.61	94.99
SYACIUM GUNTERI	1484	0.44	95.43
PORICHTHYS POROSISSIMUS	1462	0.43	95.86
PRIONOTUS TRIBULUS	1418	0.42	96.28
PRIONOTUS RUBIO	1170	0.35	96.63
ETROPUS CROSSOTUS	1064	0.32	96.94
STENOTOMUS CAPRINUS	919	0.27	97.22
ANCHOA LYOLEPIS	809	0.24	97.46
SELENE SETAPINNIS	781	0.23	97.69
SPHOEROIDES PARVUS	766	0.23	97.92
CENTROPRISTIS PHILADELPHIC	687	0.20	98.12
ORTHOPRISTIS CHRYSOPTERA	597	0.18	98.30
SYMPHURUS CIVITATUS	581	0.17	98.47
CITHARICHTHYS SPILOPTERUS	489	0.15	98.61
BAIROIELLA CHRYSOURA	453	0.13	98.75
CHAETODIPTERUS FABER	329	0.10	98.85
BAGRE MARINUS	310	0.09	98.94
OPISTHONEMA OGLINUM	289	0.09	99.02
LEPOPHIDIUM GRAELLSI	267	0.08	99.10
HALIEUTICHTHYS ACULEATUS	257	0.08	99.18
CARANX HIPPOS	212	0.06	99.24
UROPHYCIS FLORIDANUS	212	0.06	99.31
DIPLECTRUM BIVITTATUM	202	0.06	99.36
PARALICHTHYS LETHOSTIGMA	164	0.05	99.41
OGCOCEPHALUS SP.	144	0.04	99.46
SCOMBEROMORUS CAVALLA	118	0.03	99.49
LAGODON RHOMBOIDES	113	0.03	99.52
GYMNACHIRUS TEXAE	112	0.03	99.56
SYNODUS FOETENS	98	0.03	99.59
PRIONOTUS SALMONICOLOR	97	0.03	99.62
RHIZOPRIONODON TERRAENOVAE	93	0.03	99.64
LUTJANUS CAMPECHANUS	87	0.03	99.67
SERRANICULUS PUMULIO	84	0.02	99.69
SYMPHURUS PLAGIUSA	77	0.02	99.72
SAURIDA BRASILIENSIS	65	0.02	99.74
UPENEUS PARVUS	65	0.02	99.76

Table 4-12. (Continued).

MENTICIRRHUS LITTORALIS	63	0.02	99.77
ENGRAULIS EURYSTOLE	61	0.02	99.79
ASTROSCOPUS Y-GRAECUM	56	0.02	99.81
HEMICARANX AMBLYRHYNCHUS	51	0.02	99.82
OPHIDION WELSHI	43	0.01	99.84
ACHIRUS LINEATUS	40	0.01	99.85
PRIONOTUS OPHRYAS	38	0.01	99.86
POMATOMUS SALTATOR	29	0.01	99.87
DASYATIS SABINA	27	0.01	99.88
SCOMBEROMORUS MACULATUS	27	0.01	99.88
SPHYRAENA GUACHANCHO	26	0.01	99.89
DOROSOMA PETENENSE	25	0.01	99.90
ANCYLOPSETTA QUADROCELLATA	24	0.01	99.91
LAGOCEPHALUS LAEVIGATUS	21	0.01	99.91
SPHYRNA TIBURO	20	0.01	99.92
TRACHINOTUS CAROLINUS	19	0.01	99.92
SCORPAENA CALCARATA	19	0.01	99.93
BROTULA BARBATA	17	0.01	99.94
CHILOMYCTERUS SCHOEPFI	17	0.01	99.94
BALISTES CAPRISCUS	16	0.00	99.94
ARCHOSARGUS PROBATOCEPHALU	13	0.00	99.95
LUTJANUS SYNAGRIS	13	0.00	99.95
PRIONOTUS SCITULUS	12	0.00	99.96
CYCLOPSETTA CHITTENDENI	11	0.00	99.96
SYNGNATHUS LOUISIANAE	9	0.00	99.96
SARDINELLA AURITA	9	0.00	99.96
CARANX CRYSOS	9	0.00	99.97
MENIDIA BERYLLINA	8	0.00	99.97
EUCINOSTOMUS ARGENTEUS	8	0.00	99.97
PARALICHTHYS ALBIGUTTA	7	0.00	99.97
SELENE VOMER	6	0.00	99.98
RHINOPTERA BONASUS	6	0.00	99.98
POGONIAS CROMIS	6	0.00	99.98
ELOPS SAURUS	5	0.00	99.98
EUCINOSTOMUS MELANOPTERUS	4	0.00	99.98
SYNODUS POEYI	4	0.00	99.98
MUGIL CEPHALUS	4	0.00	99.98
EUCINOSTOMUS GULA	3	0.00	99.99
STEPHANOLEPIS HISPIDUS	3	0.00	99.99
OLIGOPLITES SAURUS	3	0.00	99.99
DASYATIS SAYI	3	0.00	99.99
OPHIDION HOLBROOKI	2	0.00	99.99
ETRUMEUS TERES	2	0.00	99.99
OPHIDION GRAYI	2	0.00	99.99
PRIACANTHUS ARENATUS	2	0.00	99.99
STEPHANOLEPIS SETIFER	2	0.00	99.99
ECHIOPSIS PUNCTIFER	2	0.00	99.99
TRINECTES MACULATUS	2	0.00	99.99
GYMNOTHORAX NIGROMARGINATU	2	0.00	99.99
SCIAENOPS OCELLATA	2	0.00	99.99
MUSTELUS CANIS	2	0.00	99.99
PRIONOTUS PARALATUS	2	0.00	99.99
PAREQUES UMBROSUS	1	0.00	99.99
ALOSA CHRYSOCHLORIS	1	0.00	99.99
SPHYRNA LEWINI	1	0.00	100.00
MEMBRAS MARTINICA	1	0.00	100.00
DASYATIS AMERICANUS	1	0.00	100.00
PRISTIPOMOIDES AQUILONARIS	1	0.00	100.00
GOBIONELLUS HASTATUS	1	0.00	100.00
GOBIESOX STRUMOSUS	1	0.00	100.00
SYACIUM PAPILLOSUM	1	0.00	100.00
CYNOSCION NEBULOSUS	1	0.00	100.00
CONODON NOBILIS	1	0.00	100.00
CARCHARHINUS PLUMBEUS	1	0.00	100.00
CARCHARHINUS POROSUS	1	0.00	100.00

Table 4-12. (Continued).

ECHENEIS NAUCRATES	1	0.00	100.00
ENGYOPHRYS SENTA	1	0.00	100.00
TOTAL	337165		

Table 4-13. Composition of dominant and non-dominant species of fish. Offshore area. October 1977-February 1980.

Dominant Species (11)	Number	%	Cum. %
STENOTOMUS CAPRINUS	13737	22.44	22.44
SYACIUM GUNTERI	7917	12.93	35.38
CHLOROSCOMBRUS CHRYSURUS	5823	9.51	44.89
UPENEUS PARVUS	4084	6.67	51.56
TRACHURUS LATHAMI	3972	6.49	58.05
DIPLECTRUM BIVITTATUM	3750	6.13	64.18
SAURIDA BRASILIENSIS	2042	3.34	67.51
SYNODUS FOETENS	1640	2.68	70.19
PEPRILUS BURTI	1556	2.54	72.73
PRIACANTHUS ARENATUS	1340	2.19	74.92
CENTROPRISTIS PHILADELPHIC	1231	2.01	76.94
Non-Dominant Species (102)			
PRIONOTUS RUBIO	1156	1.89	78.82
PRIONOTUS PARALATUS	912	1.49	80.31
PORICHTHYS POROSISSIMUS	866	1.41	81.73
SPHOEROIDES PARVUS	866	1.41	83.14
CYNOSCION ARENARIUS	765	1.25	84.39
SCORPAENA CALCARATA	735	1.20	85.59
LAGODON RHOMBOIDES	651	1.06	86.66
LUTJANUS CAMPECHANUS	627	1.02	87.68
SERRANUS ATROBRANCHUS	607	0.99	88.67
PRISTIPOMOIDES AQUILONARIS	573	0.94	89.61
MICROPOGONIAS UNDULATUS	480	0.78	90.39
ETROPUS CROSSOTUS	474	0.77	91.17
SYNODUS POEYI	471	0.77	91.94
LAGOCEPHALUS LAEVIGATUS	426	0.70	92.63
ENGYOPHRYS SENTA	413	0.67	93.31
LEPOPHIDIUM GRAELLSI	398	0.65	93.96
PRIONOTUS STEARNSI	363	0.59	94.55
ANCHOA HEPSETUS	357	0.58	95.13
HALIEUTICHTHYS ACULEATUS	297	0.49	95.62
LEIOSTOMUS XANTHURUS	250	0.41	96.03
PRIONOTUS SALMONICOLOR	214	0.35	96.38
TRICHIURUS LEPTURUS	209	0.34	96.72
GYMNACHIRUS TEXAE	196	0.32	97.04
CYCLOPSETTA CHITTENDENI	195	0.32	97.36
OGCOCEPHALUS SP.	187	0.31	97.66
BOLLMANNIA COMMUNIS	159	0.26	97.92
CYNOSCION NOTHUS	148	0.24	98.16
ANCHOA MITCHILLI	111	0.18	98.35
ETRUMEUS TERES	75	0.12	98.47
PRIONOTUS OPHRYAS	58	0.09	98.56
ANCYLOPSETTA QUADROCELLATA	55	0.09	98.65
SYMPHURUS CIVITATUS	51	0.08	98.74
SELENE SETAPINNIS	50	0.08	98.82
BELLATOR MILITARIS	49	0.08	98.90
DECAPTERUS PUNCTATUS	42	0.07	98.97
CITHARICHTHYS SPILOPTERUS	42	0.07	99.04
ANCHOA LYOLEPIS	40	0.07	99.10
UROPHYCIS FLORIDANUS	34	0.06	99.16
PAREQUES UMBROSUS	34	0.06	99.21
CHAETODIPTERUS FABER	32	0.05	99.26
ORTHOPRISTIS CHRYSOPTERA	31	0.05	99.32
BALISTES CAPRISCUS	31	0.05	99.37

Table 4-13. (Continued).

BREGMACEROS ATLANTICUS	29	0.05	99.41
HARENGULA JAGUANA	24	0.04	99.45
RAJA TEXANA	23	0.04	99.49
STEPHANOLEPIS HISPIDUS	23	0.04	99.53
SYMPHURUS DIOMEDIANUS	23	0.04	99.56
RHIZOPRIONODON TERRAENOVAE	17	0.03	99.59
ANTENNARIUS RADIOSUS	16	0.03	99.62
CAULOLATILUS INTERMEDIUS	16	0.03	99.64
LUTJANUS SYNAGRIS	15	0.02	99.67
UROPHYCIS CIRRATUS	13	0.02	99.69
BROTULA BARBATA	11	0.02	99.71
SPHYRAENA GUACHANCHO	11	0.02	99.73
OPISTHONEMA OGLINUM	11	0.02	99.74
ANCYLOPSETTA DILECTA	10	0.02	99.76
PARALICHTHYS LETHOSTIGMA	10	0.02	99.78
MULLUS AURATUS	9	0.01	99.79
EUCINOSTOMUS ARGENTEUS	9	0.01	99.81
PRIONOTUS ROSEUS	8	0.01	99.82
SELAR CRUMENOPHTHALMUS	7	0.01	99.83
PEPRILUS PARU	7	0.01	99.84
SPHOEROIDES DORSALIS	7	0.01	99.85
SCOMBER JAPONICUS	6	0.01	99.86
SPHYRNA TIBURO	6	0.01	99.87
EUCINOSTOMUS GULA	5	0.01	99.88
PRIONOTUS TRIBULUS	5	0.01	99.89
PARALICHTHYS ALBIGUTTA	5	0.01	99.90
SERRANICULUS PUMULIO	5	0.01	99.91
GYMNOTHORAX NIGROMARGINATU	5	0.01	99.91
ECHENEIS NAUCRATES	4	0.01	99.92
MENTICIRRHUS AMERICANUS	4	0.01	99.93
HAEMULON AUROLINEATUM	3	0.00	99.93
BREVOORTIA PATRONUS	3	0.00	99.94
SCOMBEROMORUS CAVALLA	3	0.00	99.94
MUSTELUS CANIS	3	0.00	99.95
HOPLUNNIS MACRURUS	3	0.00	99.95
HOPLUNNIS TENUIS	3	0.00	99.96
LONCHOPISTHUS LINDNERI	2	0.00	99.96
LARIMUS FASCIATUS	2	0.00	99.96
CANTHERHINES PULLUS	1	0.00	99.97
SARDINELLA AURITA	1	0.00	99.97
PHRYNELOX SCABER	1	0.00	99.97
CARANX CRYSOS	1	0.00	99.97
ACANTHOSTRACION QUADRICORN	1	0.00	99.97
SYACIUM PAPILLOSUM	1	0.00	99.97
STEPHANOLEPIS SETIFER	1	0.00	99.97
RHOMBOPLITES AURORUBENS	1	0.00	99.98
SERRANUS SUBLIGARIUS	1	0.00	99.98
DACTYLOPTERUS VOLITANS	1	0.00	99.98
ARCHOSARGUS PROBATOCEPHALU	1	0.00	99.98
PAREXOETUS BRACHYPTERUS	1	0.00	99.98
SELENE VOMER	1	0.00	99.98
TRACHINOCEPHALUS MYOPS	1	0.00	99.99
TRICHOPSETTA VENTRALIS	1	0.00	99.99
PARALICHTHYS SQUAMILENTUS	1	0.00	99.99
HIPPOCAMPUS ERECTUS	1	0.00	99.99
CARCHARHINUS ACRONOTUS	1	0.00	99.99
SYMPHURUS UROSPILUS	1	0.00	99.99
POGONIAS CROMIS	1	0.00	100.00
SPHOEROIDES SPENGLERI	1	0.00	100.00
CITHARICHTHYS MACROPS	1	0.00	100.00
TOTAL	61210		

Penaeus aztecus dominated the shrimp catch in the offshore area and made up 92% of the total. Penaeus duorarum (8%) and P. setiferus (< 1%) were much less important.

Eleven abundant species made up 77% of the ichthyofauna in the offshore area while 102 other species made up the remaining 23%. Stenotomus caprinus (22%) dominated the offshore ichthyofauna followed by Syacium gunteri (13%) and Chloroscombrus chrysurus (10%). Other abundant species include Upeneus parvus (7%), Trachurus lathami (6%), Diplectrum bivittatum (6%), Saurida brasiliensis (3%) Synodus foetens (3%), Peprilus burti (3%), Priacanthus arenatus (2%) and Centropristis philadelphica (2%).

4.5.4 Section Discussion

Station sets delineated by cluster analysis generally agree with groupings previously selected. Cluster analysis suggested that stations 9, 10, and 26 could be described with the defined diffuser area, although stations 9 and 10 were slightly dissimilar and were in different depths. However, previous station groupings were maintained in order to keep the defined diffuser area as homogeneous as possible and for convenient description of fauna inshore and offshore of the diffuser area. This action is supported by findings (Section 4.13) that certain important nekton show different percentage compositions at stations 9, 10, and 26 than they do at the stations in the defined diffuser area.

The inshore area was characterized by nekton of the white shrimp community. The fauna was dominated by P. setiferus and fishes of the family Sciaenidae, especially Micropogonias undulatus, Cynoscion nothus, Stellifer lanceolatus, and Cynoscion arenarius. Important supporting

families and species of fishes included the family Stromateidae (Peprilus burti; P. paru), Ariidae (Ariopsis felis), and Engraulidae (Anchoa mitchilli). Pelagic fishes, notably Chloroscombrus chrysurus, of the family Carangidae, were abundant. With few exceptions, notably the pelagic fishes, the inshore fauna was similar to the fauna of the white shrimp community reported by Chittenden and McEachran (1976).

The offshore area was characterized by nekton of the brown shrimp community. The fauna was dominated by P. aztecus and Stenotomus caprinus of the family Sparidae. A rich variety of families and species made up important supporting fauna, including the Bothidae (Syacium gunteri), Mullidae (Upeneus parvus), Serranidae (Diplectrum bivittatum and Centropristis philadelphica), and Synodontidae (Synodus foetens and Saurida brasiliensis). Widely distributed pelagic fishes of the families Carangidae (Chloroscombrus chrysurus and Trachurus lathami) and Stromateidae (Peprilus burti) were abundant as were fish (Priacanthus arenatus) typically associated with areas of broken relief. With few exceptions, notably the pelagic forms again, the fauna of the brown shrimp community was similar to that reported by Chittenden and McEachran (1976) and Chittenden and Moore (1977).

4.6 Trends in Nekton Abundance by Station and Depth off Freeport

The Penaeid shrimp community and the fish community each showed trends in abundance related to stations and depths during the period October 1977-February 1980. Figure 4-3 and Appendix Table 7-5 describe these trends by expressing abundance as the arithmetic mean catch per tow based on all collections in that period. Among station trends in abundance for the diffuser area are presented in Sections 4.15 and 4.16.

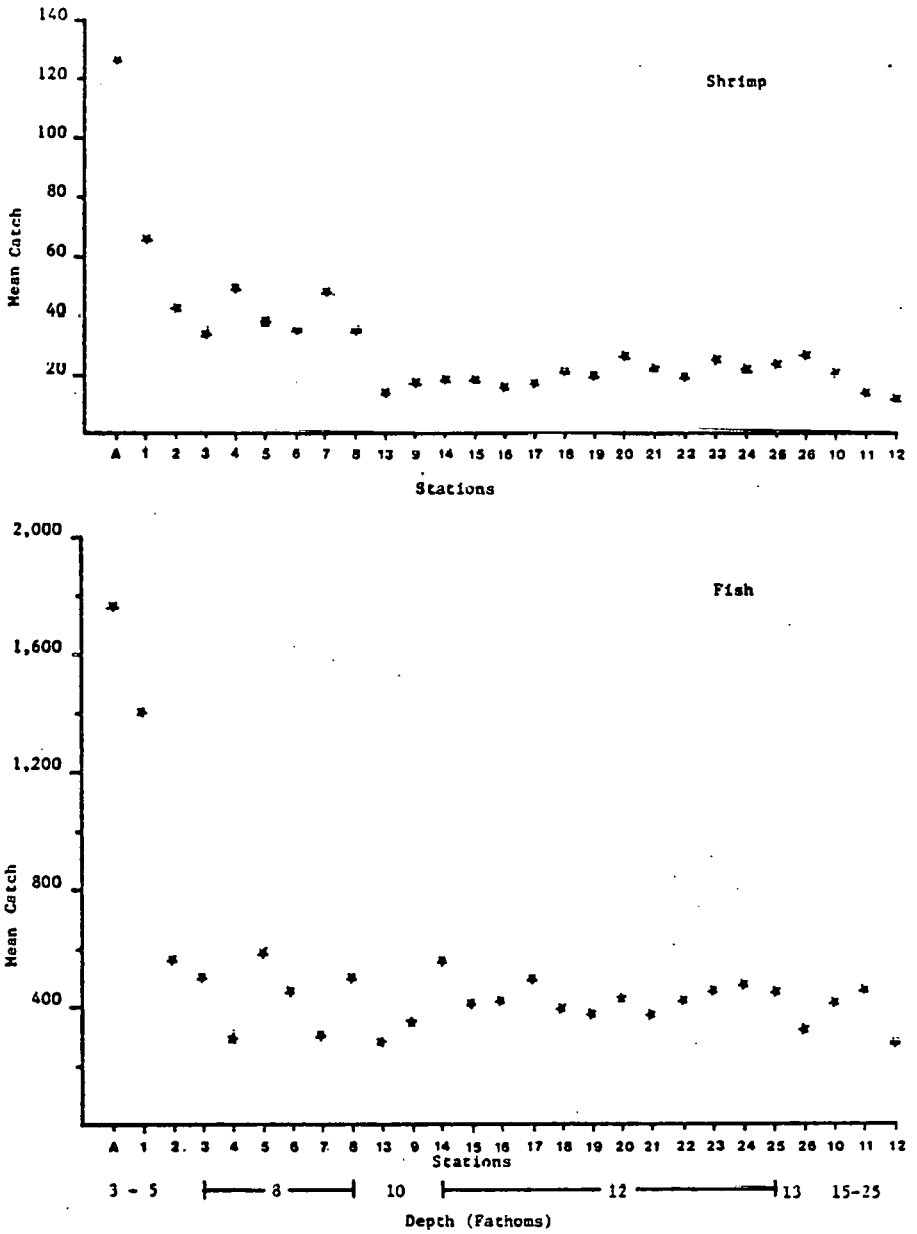

Figure 4-3. Trends by station and depth in mean abundance of Penaeid shrimp and fish. Sample sizes, total catches, and mean catches are presented in Appendix Table 4-5.

The fish community showed a distinct decrease in abundance with change in stations reflecting greater distance from shore and increasing depth. Abundance was greatest by far at stations A and 1 which are furthest inshore and lie in 3-5 fathoms. Abundance sharply declined further from shore in waters of 5 fathoms. Abundance of fish did not greatly change in waters of 7-25 fathoms, so that differences between stations were not large. However, abundance continued to gradually decrease with increasing depth. The low catches at stations 4, 7, and 13 probably reflect the fact that collections at these discontinued stations primarily were made in the late fall, early winter periods when fish abundance approached its annual minimums.

The Penaeid shrimp community also showed a distinct decrease in abundance with increasing depth and distance from shore. Shrimp catches were greatest by far at station A, followed by catches at station 1. Shrimp catches were much higher at stations(2-8) in 8 fathom depths than at stations in deeper water. The lower Penaeid catch at stations 10-12 reflects the fact that many collections there were made during the daylight. Penaeus aztecus is abundant in that area, but few were captured there in daytime.

4.6.1 Section Discussion

Trends in Penaeid shrimp abundance largely reflect transition from a white shrimp to a brown shrimp community. Both species of shrimp emigrate to the Gulf from estuarine nurseries (Moffett 1970), so that both could be collected at the inshore stations. Penaeus setiferus primarily has an inshore bathymetric range (Hann et al. 1979), so that fewer individuals of this species would be near the diffuser, and virtually none would be in deeper water at stations 10, 11, and 12. Therefore, collections at the inshore stations could capture two important Penaeid species whereas

only one would be collected in deep water.

The between stations trend in fish abundance in the present studies is similar to Hildebrand's (1954) observation of greatest catches in the white shrimp community. Chittenden and McEachran (1976) reported greatest catches in the brown shrimp community, but they made quarterly cruises only, and month to month variation in catches might account for their findings.

4.7 Monthly Trends in Nekton Abundance off Freeport

The fish community and the Penaeid shrimp each showed monthly trends in abundance. Figures 4-4 - 4-7 and Appendix Tables 7-6 and 7-7 describe these trends as arithmetic mean catch per tow based on all data collected in the period October 1977-January 1980 for the defined inshore and offshore areas. Trends in the diffuser area, which is of special importance, are presented in Sections 4.15 and 4.16.

Fish abundance showed similar monthly patterns in the inshore and offshore areas. Fishes were most abundant in the warmer months of May-October (Figures 4-6, 4-7). Abundance then declined during fall to minimum levels in the colder months of December-April. Catch variation within months was small in all areas during the period October-May but differed between areas in the summer. There was great catch variation in the inshore area during summer. The instances of extremely low catches in the inshore area during June and July were probably due to low dissolved oxygen levels as described in Section 4-9. Extremely low catches were not made during the summer in the offshore area, and catch variation was not as great as in the inshore area.

Penaeid shrimp abundance also showed definite monthly trends depending

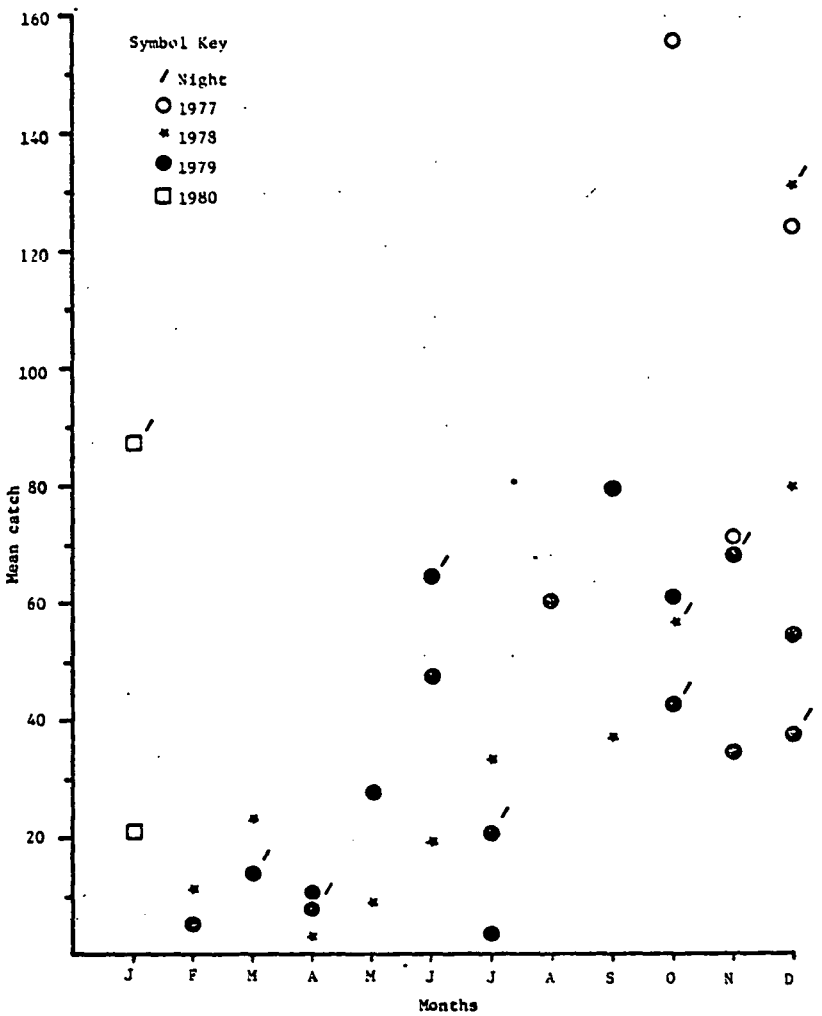

Figure 4-4. Monthly trends in the mean abundance of Penaeid shrimp in the inshore area. Sample sizes, total catches, and mean catches are presented in Appendix Tables.

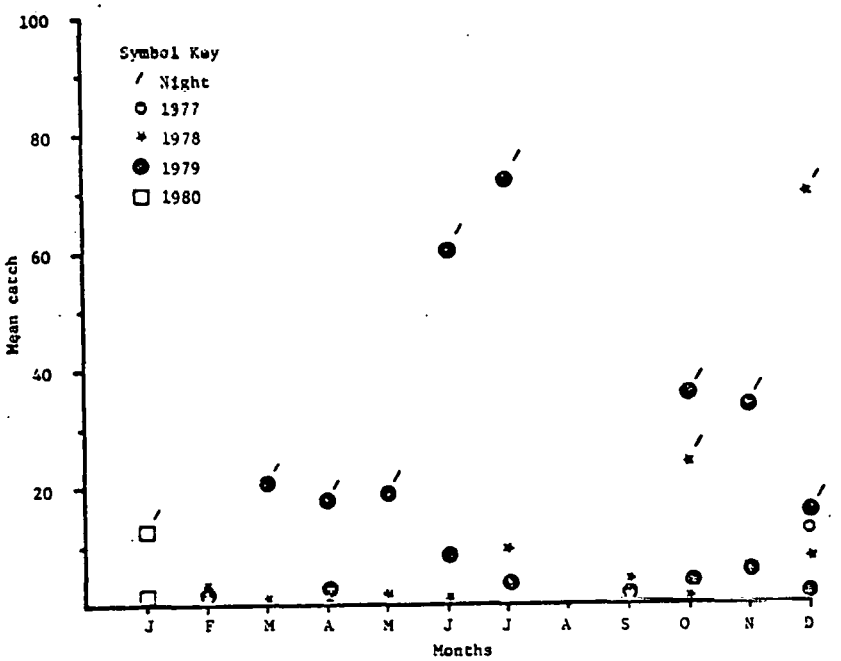

Figure 4-5. Monthly trends in the mean abundance of Penaeid shrimp in the offshore area. Sample sizes, total catches, and mean catches are presented in Appendix Tables.

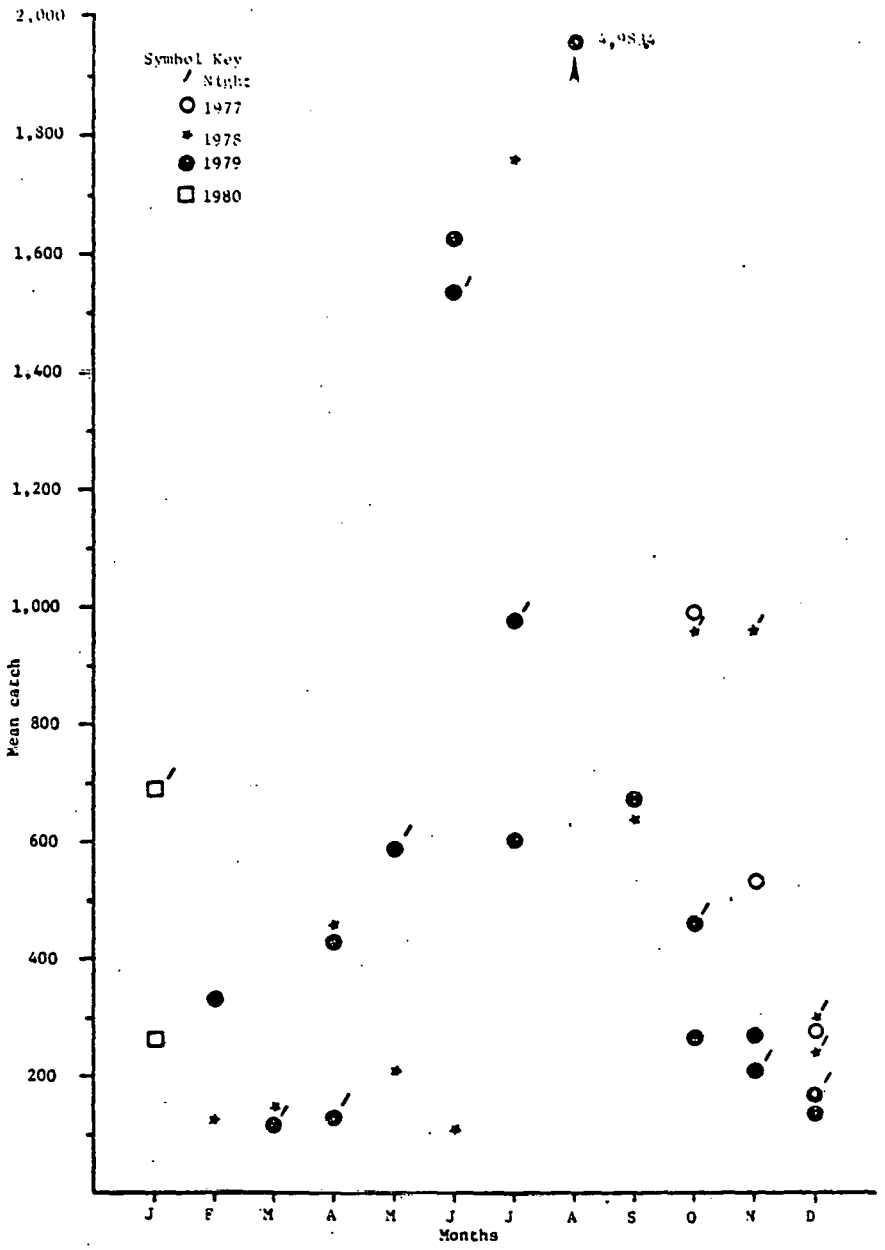

Figure 4-6. Monthly trends in the mean abundance of fish in the Inshore area. Sample sizes, total catches, and mean catches are presented in Appendix Tables.

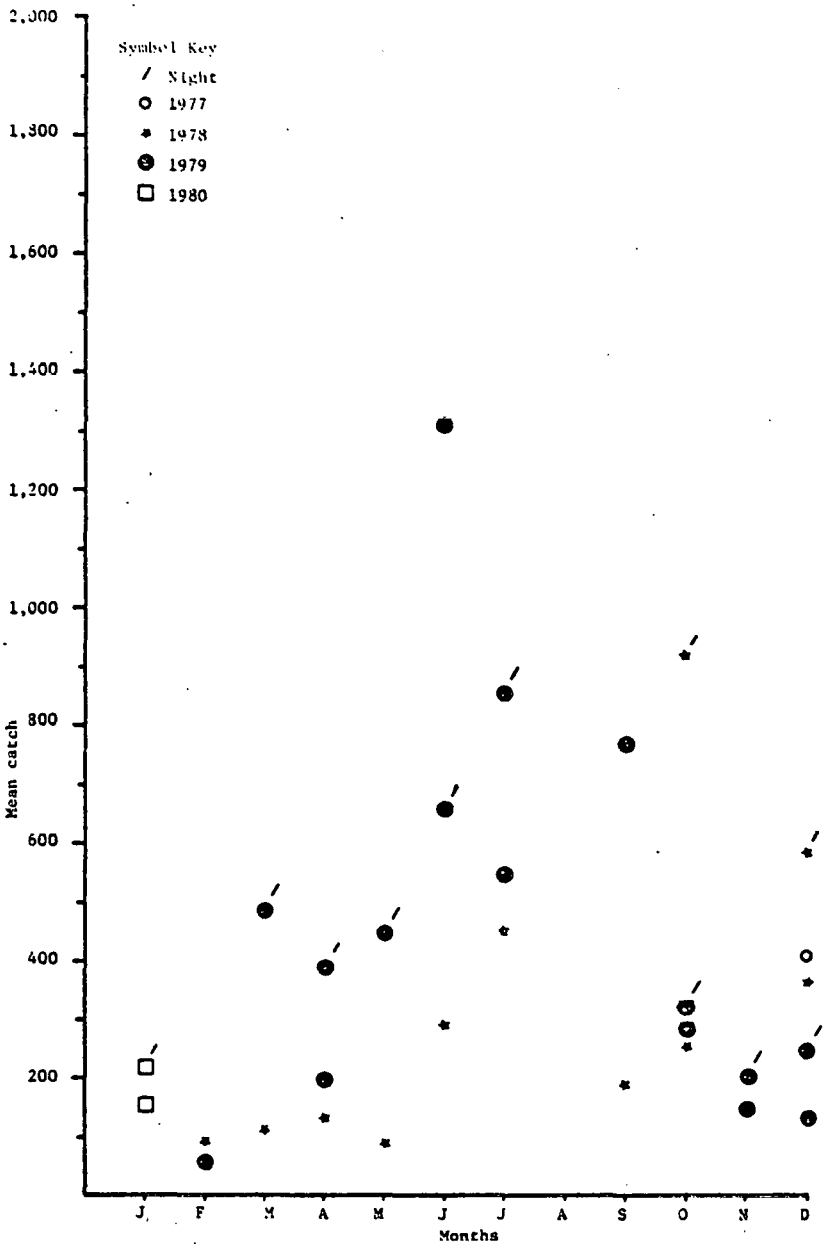

Figure 4-7. Monthly trends in the mean abundance of fish in the offshore area. Sample sizes, total catches, and mean catches are presented in Appendix Tables.

upon area. Penaeid abundance was greatest in the inshore area during September-December (Figure 4-4) when P. setiferus enters the Gulf. Penaeid abundance in that area declined after December, remained low through May, and rose in June when P. aztecus enters the Gulf. Low Penaeid catches during June and July probably reflected low oxygen conditions.

Apparent trends in Penaeid abundance in the offshore area (Figure 4-5) may be misleading. Penaeus aztecus, the dominant offshore species, is nocturnal offshore, but most collections there were made during the day. Night collections in 1979 and 1980 showed minimum abundance from January-May, greatly increased abundance during June and July, and high but declining abundance during the fall.

4.7.1 Section Discussion

The annual cycle of fish abundance observed in the present studies is similar to that described in many accounts (see Chittenden and McEachran 1976, pg. 28 for references). A great reduction in biomass and abundance in the inshore waters during the winter generally has been observed in the warm temperate Carolinean Province from Cape Hatteras, North Carolina through the northern Gulf of Mexico, and such trends specifically have been described for Texas waters (Gunter 1945, 1958 ; McFarland 1963; and Chittenden and McEachran 1976). These changes reflect the poorly known seasonal movements of the fishes and their rapid turnover, short life spans, and extremely high annual mortality rates (Chittenden and McEachran 1976; Chittenden 1977; White and Chittenden 1977; De Vries 1979; and Shlossman 1980).

The annual cycle of Penaeid shrimp abundance observed in this study

is similar to that described by Van Lopik et al. (1979) and is related to life history patterns. Seasonally increased abundance inshore coincides with migrations of P. aztecus and P. setiferus to the Gulf from estuarine nurseries. Penaeus aztecus migrates through inshore waters to offshore waters where it is dominant year-round, but P. setiferus generally remains inshore as noted earlier in these studies (Hann et al. 1979).

4.8 Seasonal and Monthly Compositions of the Penaeid Shrimp Fauna and Ichthyofauna off Freeport

Compositions of the Penaeid shrimp fauna and the ichthyofauna show seasonal and monthly patterns superimposed on the community changes with depth that are described in Sections 4.5 and 4.11. The present section describes seasonal trends for the defined inshore area and for the defined offshore area (Tables 4-14-4-18). Trends in the diffuser area, which are of special interest, are described in Sections 4.15 and 4.16.

Monthly compositions of the abundant fishes and shrimp are presented in Appendix Tables 7-8-7-20, but they are not specifically discussed.

4.8.1 Seasonal Trends in the Inshore Area

Penaeid shrimp composition exhibited seasonal trends in the inshore area. Penaeus setiferus was dominant during the winter. Young P. aztecus were a dominant in the spring, probably reflecting their migration from estuarine nurseries. Penaeus setiferus were also important in the spring and P. duorarum reached its greatest level then. Penaeus setiferus was dominant in the summer and fall and reached peak abundance in the fall.

The dominant ichthyofauna showed distinct seasonal trends in the inshore area. During summer, the dominant taxa included members of the

Table 4-14. Summary of the very abundant ichthyofauna, by area, off Freeport in summer (July, Aug., Sept.). See text for definition of areas. Asterisks indicate the number of areas in which a species was a major faunal element, if more than one; and D indicates a species made up 15% or more of the catch on at least one occasion.

Inshore Area	Diffuser Area	Offshore Area
Trachurus lathami ***D	Trachurus lathami ***D	Trachurus lathami ***D
Chloroscombrus chrysurus ***D	Chloroscombrus chrysurus ***D	Chloroscombrus chrysurus ***
Peprilus burti ***	Peprilus burti ***	Peprilus burti ***D
Micropogonias undulatus **D	Micropogonias undulatus **	
Cynoscion nothus **	Cynoscion nothus **	
Cynoscion arenarius **		Cynoscion arenarius **
Anchoa hepsetus **D	Anchoa hepsetus ***D	
Harengula jaguana**	Harengula jaguana **	Prionotus rubio **D
	Prionotus rubio **D	Syacium gunteri D
Stellifer lanceolatus D		Stenotomus caprinus D
Peprilus paru D	Syacium gunteri **	Upeneus parvus D
Ariopsis felis D	Lepophidium graellsi D	
Brevoortia patronus	Anchoa lyolepis	Diplectrum bivittatum
Leiostomus xanthurus	Centropristis philadelphica	Porichthys porosissimus
	Opisthonema oglinum	Anchoa hepsetus ***
	Leiostomus xanthurus*	

Table 4-15. Summary of the very abundant ichthyofauna, by area, off Freeport in fall (Oct., Nov., Dec.). See text for definition of areas. Asterisks indicate the number of areas in which a species was a major faunal element, if more than one; and D indicates a species made up 15% or more of the catch on at least one occasion.

Inshore Area	Diffuser Area	Offshore Area
Chloroscombrus chrysurus ***D	Chloroscombrus chrysurus ***D	Chloroscombrus chrysurus ***D
Peprilus burti ***D	Peprilus burti ***D	Peprilus burti ***
Syacium gunteri ***	Syacium gunteri ***D	Syacium gunteri ***D
Micropogonias undulatus **D		Micropogonias undulatus **
Cynoscion nothus ***D	Cynoscion nothus ***D	
Ariopsis felis **	Ariopsis felis **	
Porichthys porosissimus **	Porichthys porosissimus **D	
Anchoa hepsetus ** D	Anchoa hepsetus **D	
Prionotus rubio **	Prionotus rubio **	
	Stenotomus caprinus **	Stenotomus caprinus **D
	Diplectrum bivittatum **	Diplectrum bivittatum **D
	Upeneus parvus **	Upeneus parvus **D
	Trachurus lathami **D	Trachurus lathami **
	Saurida brasiliensis **D	Saurida brasiliensis **
Cynsocion arenarius **D	Centropristis philadelphica	Synodus foetens
Stellifer lanceolatus D	Halieutichthys aculeatus	Leiostomus xanthurus
Trichiurus lepturus D		
Anchoa mitchilli D		
Harengula jaguana D		
Menticirrhus americanus		
Etropus crossotus		

Table 4-16. Summary of the very abundant ichthyofauna, by area, off Freeport in the winter (Jan., Feb., Mar.). See text for definitions of areas. Asterisks indicate the number of areas in which a species was a major faunal element, if more than one; and D indicates a species made up 15% or more of the catch on at least one occasion.

Inshore Area	Diffuser Area	Offshore Area
Peprilus burti ***	Peprilus burti *** D	Peprilus burti ***
Syacium gunteri ***	Syacium gunteri *** D	Syacium gunteri ***
Cynoscion nothus ** D	Cynoscion nothus ** D	
Anchoa mitchilli ** D		Anchoa mitchilli ** D
Etropus crossotus **	Etropus crossotus **	
Centropristis philadelphica **	Saurida brasiliensis **	Saurida brasiliensis **
	Centropristis philadelphica**	
Micropogonias undulatus D		Synodus foetens
Cynoscion arenarius D		Stenotomus caprinus D
Trichiurus lepturus D		Etrumeus teres D
Larimus fasciatus		Anchoa hepsetus
Leiostomus xanthurus D		Sphoeroides parvus
Lepophidium graellsi		Diplectrum bivittatum
		Chloroscombrus chrysurus D
		Trachurus lathami
		Prionotus paralatus

Table 4-17. Summary of the very abundant ichthyofauna, by area, off Freeport in the spring (April, May, June). See text for definitions of areas. Asterisks indicate the number of areas in which a species was a major faunal element, if more than one; and D indicates a species made up 15% or more of the catch on at least one occasion.

Inshore Area	Diffuser Area	Offshore Area
Peprilus burti *** D	Peprilus burti *** D	Peprilus burti ***
Chloroscombrus chrysurus *** D	Chloroscombrus chrysurus *** D	Chloroscombrus chrysurus *** D
Trichiurus lepturus D	Trichiurus lepturus ***	Trichiurus lepturus ***
Cynoscion nothus **D	Cynoscion nothus **D	
	Diplectrum bivittatum ** D	Diplectrum bivittatum ** D
	Syacium gunteri ** D	Syacium gunteri ** D
	Anchoa hepsetus **	Anchoa hepsetus **
Menticirrhus americanus D	Cynsocion arenarius **D	Synodus foetens D
Micropogonias undulatus D	Etropus crossotus	Saurida brasiliensis D
Stellifer lanceolatus D	Urophycis floridanus	Stenotomus caprinus D
Larimus fasciatus	Priacanthus arenatus **	Centropristis philadelphica
Ariopsis felis	Porichthys porosissimus**	Trachurus lathami ** D
Brevoortia patronus	Prionotus rubio D	Harengula jaguana
Anchoa mitchilli D	Halieutichthys aculeatus	Scorpaena calcarata
Harengula jaguana D	Trachurus lathami **	Sphoeroides parvus
		Upeneus parvus
		Priacanthus arenatus **
		Porichthys Porosissimus**

Table 4-18. Summary by area and season of Penaeid shrimp percentage compositions off Freeport, Texas, October 1977-January 1980. See text for definition of areas and Tables 4-14 - 4-17 for definition of seasons.

Season	Species	Inshore	Diffuser	Offshore
Winter	Penaeus aztecus	2.87	40.38	97.55
	Penaeus duorarum	0.34	6.58	0.49
	Penaeus setiferus	96.80	53.04	1.96
Spring	Penaeus aztecus	60.28	83.91	81.16
	Penaeus duorarum	11.09	10.47	18.32
	Penaeus setiferus	28.63	5.63	0.51
Summer	Penaeus aztecus	29.77	99.51	88.26
	Penaeus duorarum	0.00	0.25	11.17
	Penaeus setiferus	70.23	0.25	0.57
Fall	Penaeus aztecus	14.22	90.53	97.73
	Penaeus duorarum	0.21	2.20	2.27
	Penaeus setiferus	85.57	7.27	0.00

Carangidae (Chloroscombrus chrysurus, and Trachurus lathami), the Sciaenidae (Micropogonias undulatus and Stellifer lanceolatus), the Ariidae (Ariopsis felis), and the Engraulidae (Anchoa hepsetus). In the fall, compositions of the dominant fauna changed. Trachurus lathami, Ariopsis felis and Anchoa hepsetus decreased in importance during fall while Chloroscombrus chrysurus, Micropogonias undulatus and Stellifer lanceolatus continued dominant. Taxa that assumed a dominant position during the fall included member of the Sciaenidae (Cynoscion arenarius and C. nothus), Clupeidae (Harengula jaguana), Stromateidae (Peprilus burti) and Engraulidae (Anchoa mitchilli). As winter began, compositions of the dominant fauna continued to change. Chloroscombrus chrysurus and Stellifer lanceolatus lost their dominant positions, but Cynoscion spp. and Micropogonias undulatus continued dominant. Taxa that assumed a dominant position during winter included members of the Sciaenidae (Leiostomus xanthurus) and Trichiuridae (Trichiurus lepturus). As spring began, compositions of the dominant fauna changed again. Several taxa resumed dominance after a hiatus during winter including members of the Carangidae (Chloroscombrus chrysurus), Sciaenidae (Stellifer lanceolatus), Stromateidae (Peprilus burti) and Clupeidae (Harengula jaguana). Several taxa continued their dominant role in the spring including Cynoscion nothus, Micropogonias undulatus, Anchoa mitchilli, and Trichiurus lepturus. One member of the Sciaenidae (Menticirrhus americanus) assumed a dominant position only in the spring, but others (Cynoscion arenarius and Leiostomus xanthurus) lost their dominant position. As summer began, compositions of the dominant fauna continued to change. Trachurus lathami, Peprilus paru, Anchoa hepsetus, and Ariopsis felis assumed a dominant role as summer began, while Cynoscion nothus, Menticirrhus americanus, Trichiurus lepturus, Peprilus burti,

and Harengula jaguana lost their dominant role. Other taxa continued their dominant roles including Chloroscombrus chrysurus, Micropogonias undulatus, and Stellifer lanceolatus.

4.8.2 Seasonal Trends in the Offshore Area

Penaeid shrimp compositions did not show distinct seasonal trends in the offshore area, because Penaeus aztecus was dominant throughout the year. However, Penaeus duorarum made up an important part of the catch in the spring and summer. Penaeus setiferus was rarely captured offshore.

The dominant ichthyofauna exhibited distinct seasonal trends in the offshore area. During summer, the dominant taxa included members of the Carangidae (Trachurus lathami), Sparidae (Stenotomus caprinus), Mullidae (Upeneus parvus), Stromateidae (Peprilus burti), Triglidae (Prionotus rubio), and Bothidae (Syacium gunteri). Compositions of the dominant fauna changed in the fall. Trachurus lathami, Peprilus burti, and Prionotus rubio decreased in importance during fall while Stenotomus caprinus, Upeneus parvus, and Syacium gunteri continued dominant. Taxa that assumed a dominant position during the fall included members of the Serranidae (Diplectrum bivittatum), and Carangidae (Chloroscombrus chrysurus). During winter, compositions of the dominant fauna continued to change. Diplectrum bivittatum and Upeneus parvus lost their dominant position while Chloroscombrus chrysurus and Stenotomus caprinus continued dominant. Taxa that assumed a dominant role during winter included members of the Clupeidae (Etrumeus teres) and Engraulidae (Anchoa mitchilli). As spring began compositions of the dominant fauna again changed. Etrumeus teres and Anchoa mitchilli lost their dominant positions, but Chloroscombrus chrysurus

and Stenotomus caprinus continued dominant. Several taxa resumed or assumed dominance during spring including members of the Synodontidae (Saurida brasiliensis and Synodus foetens), Serranidae (Diplectrum bivittatum) and Carangidae (Trachurus lathami). As summer began, compositions of the dominant fauna continued to change. Upeneus parvus, Peprilus burti, and Prionotus rubio assumed a dominant role as summer began, while Saurida brasiliensis, Synodus foetens, Diplectrum bivittatum and Chloroscombrus chrysurus decreased in importance. Several taxa continued dominant during summer including Trachurus lathami, Stenotomus caprinus, and Syacium gunteri.

4.8.3 Section Discussion

It is difficult to confidently describe reasons for the observed seasonal changes in nekton composition, because virtually no details are known about their life histories. Information on the life histories of the fourteen species initially identified and enumerated in the present studies were previously presented (Hann et al. 1979), and other recent studies describe life histories and movements off Freeport of Cynoscion nothus (DeVries 1979), C. arenarius (Shlossman 1980), Peprilus burti (Murphy, in prep.) and Stenotomus caprinus (Geoghegan, in prep.). Comments that follow further illustrate how inshore-offshore movements, recruitment patterns, etc., affect compositions, but additional life history studies are needed on nekton communities off Freeport. This discussion section integrates findings for the diffuser area (Section 4.11) to better define inshore-offshore movements.

Certain fishes, notably more or less pelagic forms such as Chloroscombrus chrysurus, Trachurus lathami, and Peprilus burti, were very

widespread in distribution, appeared abundant from 3-25 fathoms, and showed apparent inshore movements in warmer months. Chloroscombrus chrysurus was not important during winter in the inshore area or the diffuser area and presumably moved offshore where it remained important. Trachurus lathami, another member of the family Carangidae, also was important throughout the year in the offshore and diffuser areas. This species moved inshore in summer because only then was it abundant in the inshore area. Peprilus burti was widespread in distribution and important throughout the year, however, Murphy (in prep.) documents the inshore-offshore movement of the two spawned groups that this species produces each year.

Certain fishes, such as Syacium gunteri, Synodus foetens, Saurida brasiliensis, and Urophycis floridanus also show inshore-offshore movement or recruitment, but appear inshore during the colder months. Syacium was important only in the offshore area during summer but thereafter moved or recruited to the inshore and diffuser areas; it was of widespread importance during fall and winter but lost importance in the inshore area in spring. Similarly, Synodus foetens and Saurida brasiliensis were not important in the study area during summer, but they moved shoreward or recruited thereafter, because they were important in the offshore area and/or diffuser area during fall, winter and spring. Urophycis floridanus, a member of the family Gadidae, also moved inshore and was important in the colder months. It was important in the diffuser area in the spring. The closely related Urophycis regius shows similar behavior along the southeast coast of the U. S.

Certain demersal fishes, such as Ariopsis felis, show inshore-offshore movements or recruitment, but appear inshore during the warmer months. Ariopsis felis is important in the inshore fauna during summer but

apparently moves somewhere offshore during the fall to overwinter; it was important in the diffuser area in the fall but was not important anywhere in the study area in winter. It reappeared in the spring as an important member of the inshore fauna. A variety of other species, such as Polydactylus octonemus and Stellifer lanceolatus, show a similar pattern of appearance and disappearance in the inshore waters.

4.9 Effects of Low Dissolved Oxygen Conditions on Nekton off Freeport

We have observed great reductions in nekton over a broad area off Freeport on several occasions, apparently as a result of low dissolved oxygen conditions. Although we have no data on dissolved oxygen in the nekton studies, Slowey (pers. comm.) found anoxic or near anoxic conditions over a broad area of the bottom during the summer of 1979.

Unexpected and great reductions in the catches of both fishes and shrimp were observed on three occasions: 1) the June 1978 day cruise, 2) the July 1979 night cruise, 3) the July 1979 day cruise. Figures 4-8 - 4-13 express abundance of fish and shrimp during these periods as the arithmetic mean catch per tow.

Fish and Penaeid shrimp catches during the June 1979 night cruise show no instance in which nekton were virtually eliminated, although major differences appear between stations (Figures 4-8, 4-9). These data show that, at that time, very large numbers of fish--often hundreds or more per tow--and many shrimp were present near the diffuser and in the inshore area.

Nekton catches during July 1979 were virtually non-existent over an extremely large area (Figures 4-10, 4-11), in contrast to their abundance in the June 1979 night cruise. Fish were absent or virtually absent during

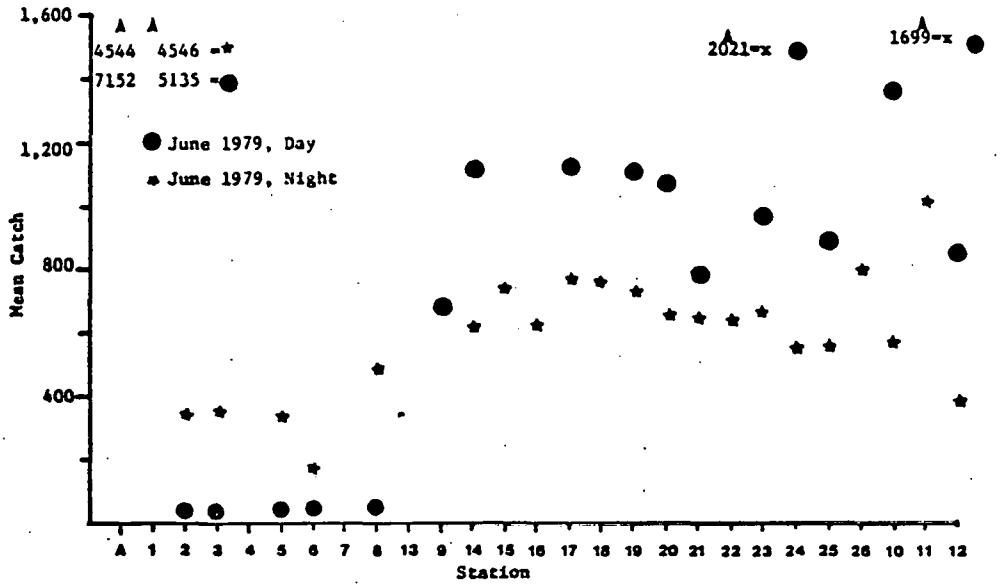

Figure 4-8. Trends in the mean abundance of fishes by station, June 1979. Sample sizes, total catches, mean catches, etc., are presented in appendix tables.

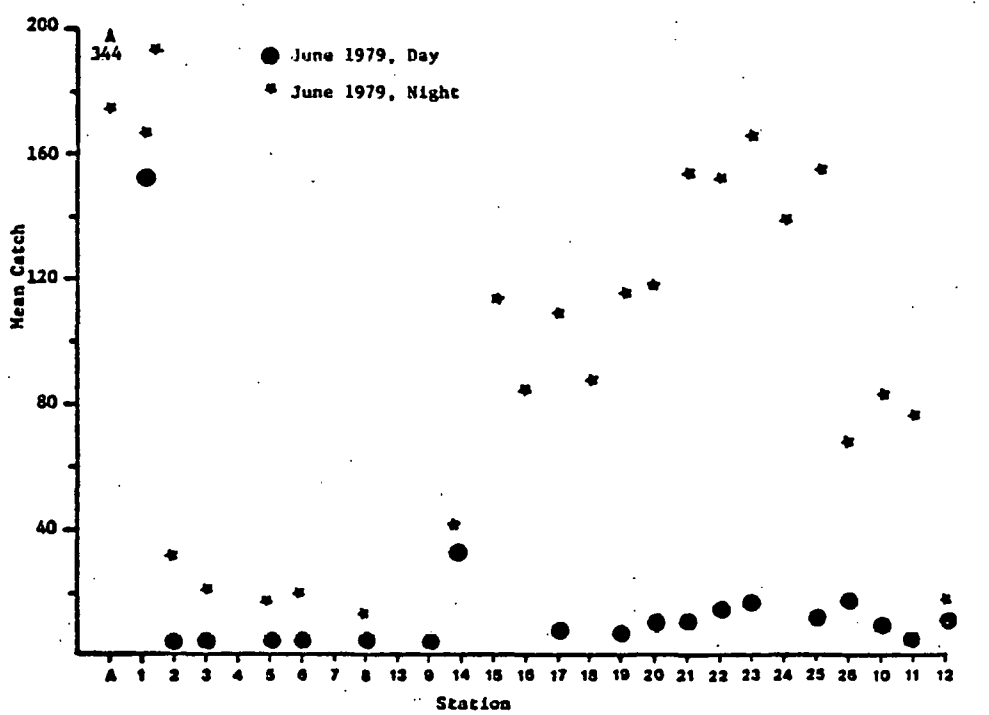

Figure 4-9. Trends in the mean abundance of Penaeid shrimp by station, June 1979. Sample sizes, total catches, mean catches, etc., are presented in the appendix tables.

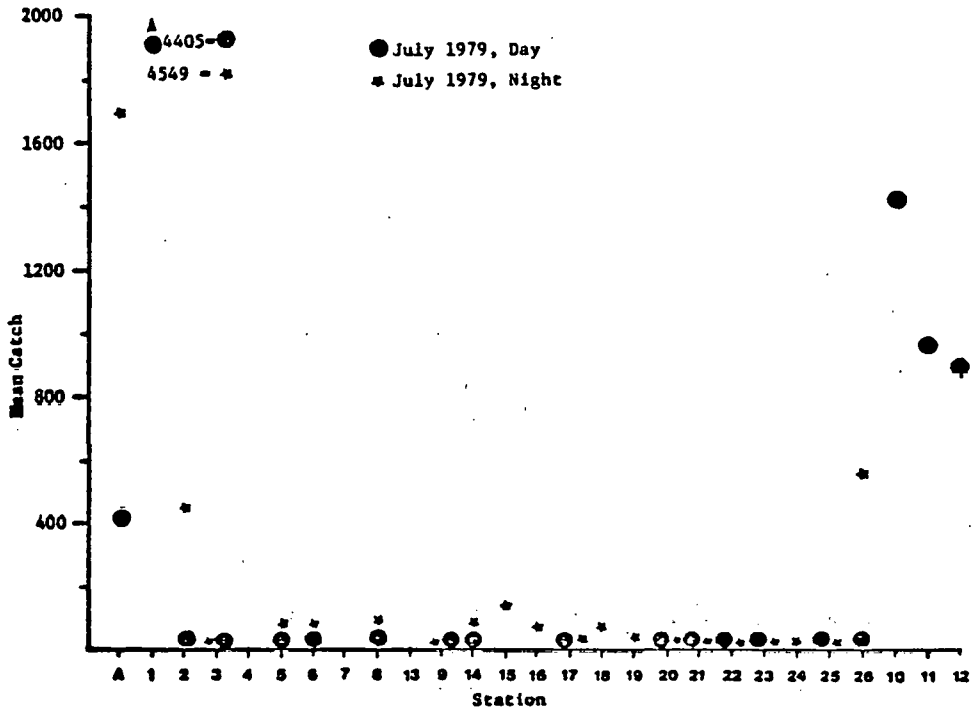

Figure 4-10. Trends in the mean abundance of fishes by station, July 1979. Sample sizes, total catches, mean catches, etc., are presented in the appendix tables.

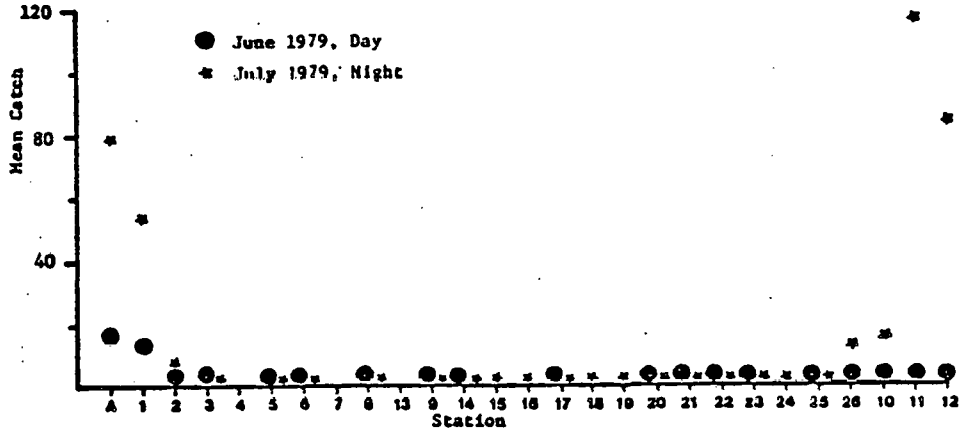

Figure 4-11. Trends in the mean abundance of Penaeid shrimp by station, July 1979. Sample sizes, total catches, mean catches, etc., are presented in the appendix tables.

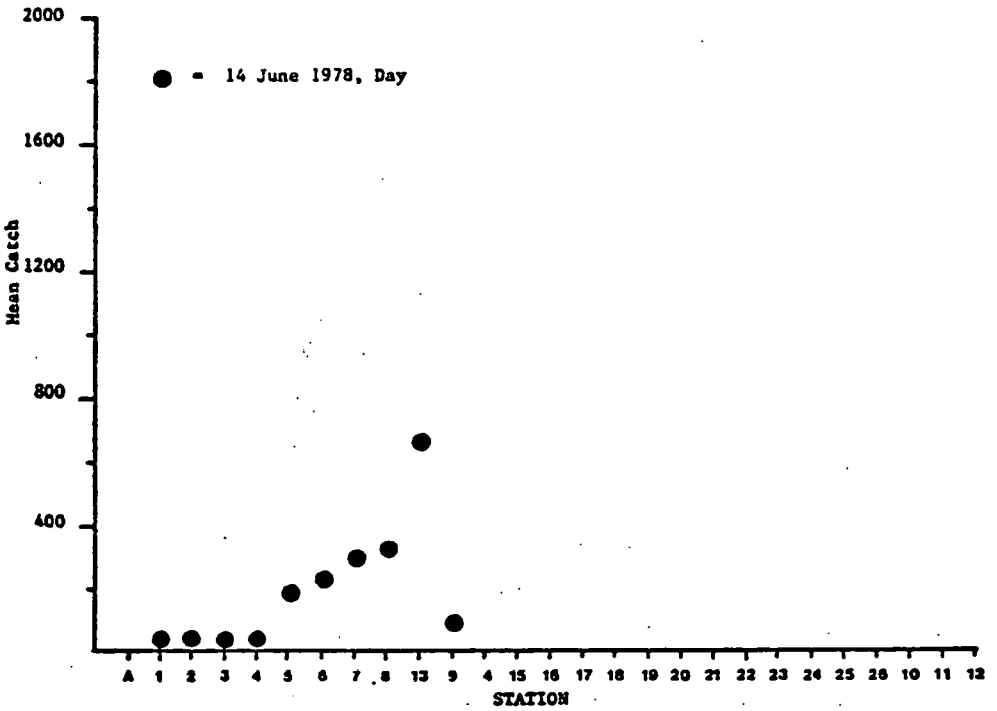

Figure 4-12. Trends in the mean abundance of fishes by station, June 1978. Sample sizes, total catches, mean catches, etc., are presented in appendix tables.

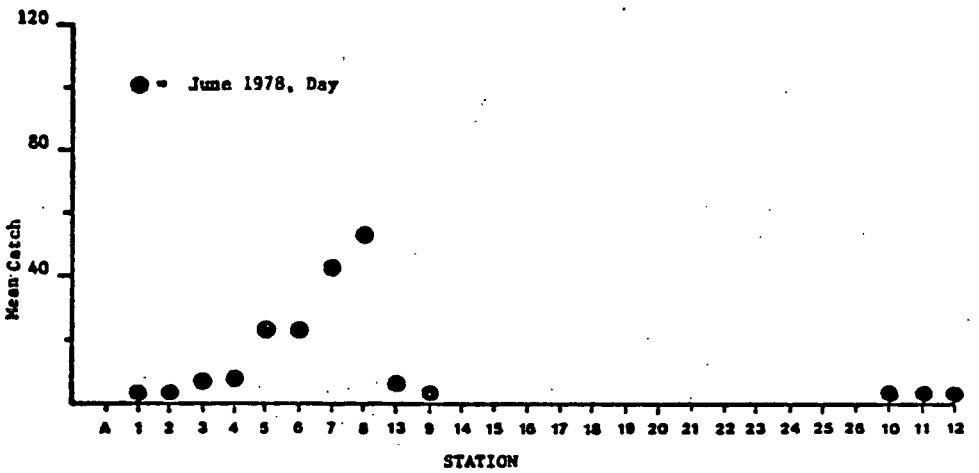

Figure 4-13. Trends in the mean abundance of Penaeid shrimp by station, June 1978. Sample sizes, total catches, mean catches, etc., are presented in appendix tables.

July from station 2 at 7 fathoms through the entire diffuser area at 12 fathoms. This condition extended even to station 26 at 13 fathoms in the July 1979 day cruise. In contrast to the afflicted area, many fishes and Penaeid shrimp were caught at stations A and 1 in 3-5 fathoms, and many fish were caught at stations 10, 11, and 12 in 15-25 fathoms. Many Penaeid shrimp were captured during the July 1979 night cruise at stations 10, 11, and 12, but few were captured during the July 1979 day cruise. This has repeatedly been noted and occurs because P. aztecus, the dominant shrimp in that area, is nocturnal in the offshore area.

Penaeid shrimp and fish catches were reduced during June 1979, but the affected area was much smaller than in July 1979 and primarily encompassed 7-8 fathom depths and stations 2-8, inclusive (Figures 4-8, 4-9). Catches increased or were very high further inshore at stations A and 1 and further offshore near the diffuser at stations 9-26, inclusive, and in deeper water.

Penaeid shrimp and fish catches in the inshore waters also were reduced during June 1978 (Figures 4-12, 4-13). Very few fish and Penaeid shrimp were caught at stations 1, 2, 3, or 4, but catches greatly increased at stations 5, 6, 7, and 8 which lie in the same 8-9 fathom depth range as stations 3 and 4 but further toward the east. We assume local low dissolved oxygen levels were associated with this pattern in June 1978 but have no dissolved oxygen data to establish it. However, blue water had penetrated widely into the inshore and diffuser areas in June 1978 as it did in 1979 when low oxygen was documented.

4.10 Comments on the Occurrence of Red Drum and Black Drum Off Freeport

Several primarily estuarine sport fishes occur in the study area,

including the red drum, Sciaenops ocellata, and the black drum, Pogonias cromis. These species support important recreational and commercial fisheries. They primarily reside in estuaries during the warm months and enter and apparently spawn in the Gulf (Pearson 1929; Simmons and Breuer 1962), but their exact spawning areas need better description. The red drum spawns off Texas about October-November, and the black drum about February-May (Pearson 1929; Simmons and Breuer 1962). The latter species may also have a secondary spawning period about July-November.

We captured these species in the study area, but not in large numbers. However, they are large active fishes that could readily avoid nets towed for short time periods. Detailed records are presented herein because of the importance of these two species.

The following occurrences describe all red drum catches to include total length, data, and station where captured:

1. December 1977, day, Station 13, one large fish, not measured;
2. November 1979, night, Station 3, 979mm;
3. January 1980, day, Station 6, 996mm; and
4. February 1980, day, Station 22, 899mm.

The following occurrences describe black drum catches:

1. December 1977, day, Station 13, one large fish, not measured;
2. December 1978, night, Station A, 910mm;
3. December 1978, day, Station 22, 677 mm;
4. April 1979, day, Station 6, 687mm;
5. May 1979, night, Station A, 221mm
6. September 1979, day, one fish, not measured;
7. November 1979, night, Station 9, 441mm;
8. December 1979, night, Station 9, 696mm;

9. February 1980, day, Station 10, one fish not measured; and Station 10, 603 mm.

Our records for red drum indicate that adults are present in depths of 8-12 fathoms during the November-February period and presumably overwintered there after spawning. Our records for black drum indicate that adults are present in depths of 3-15 fathoms with many records from 8-12 fathom depths. Black drum were captured from September through May but most were captured during winter. Evidently these species frequent depths of 8-12 fathoms, including the diffuser area, during the colder months, although our gear probably did not adequately collect them. These findings agree with Chittenden and McEachran (1976) that large Sciaenops ocellata and Pogonias cromis are common during winter in 9-11 fathom depths off Freeport.

4.11 Overall Compositions of the Penaeid Shrimp and Ichthyofauna in the Diffuser Area

This section describes overall compositions of the Penaeid shrimp and ichthyofauna in the defined diffuser area. Cluster analysis (see Section 4.5) indicated that stations in this area formed a basically homogeneous set which could be expanded to include stations 9, 10, and 26. Compositions of the ichthyofauna at these stations are presented, for comparison, in Appendix Tables 7-2, 7-3 and 7-4, respectively.

A total of 11,024 Penaeid shrimp and 239,680 fishes of 122 species were processed in the catch from 515 trawl tows at the defined diffuser area during the period July 1978-February 1980 (Tables 4-11, 4-19).

Penaeus aztecus dominated the shrimp catch in the diffuser area and made up 81% of the total. Penaeus setiferus and P. duorarum were much

Table 4-19. Composition of dominant and non-dominant species of fish. Diffuser area. October 1977-February 1980.

Dominant Species (9)	Number	%	Cum. %
CHLOROSCOMBRUS CHRYSURUS	72164	30.11	30.11
CYNOSCION NOTHUS	49518	20.66	50.77
PEPRILUS BURTI	20908	8.72	59.49
SYACIUM GUNTERI	15339	6.40	65.89
CYNOSCION ARENARIUS	10958	4.57	70.46
STENOTOMUS CAPRINUS	7904	3.30	73.76
ANCHOA HEPSETUS	7386	3.08	76.84
PRIONOTUS RUBIO	6877	2.87	79.71
TRACHURUS LATHAMI	5546	2.31	82.03
Non-Dominant Species (113)			
DIPLECTRUM BIVITTATUM	4787	2.00	84.02
MICROPOGONIAS UNDULATUS	3280	1.37	85.39
PORICHTHYS POROSISSIMUS	3227	1.35	86.74
LEIOSTOMUS XANTHURUS	3000	1.25	87.99
HALIEUTICHTHYS ACULEATUS	2665	1.11	89.10
TRICHIURUS LEPTURUS	2460	1.03	90.13
CENTROPRISTIS PHILADELPHIC	1975	0.82	90.95
ETROPUS CROSSOTUS	1871	0.78	91.73
LEPOPHIDIUM GRAELLSI	1848	0.77	92.50
SAURIDA BRASILIENSIS	1764	0.74	93.24
HARENGULA JAGUANA	1711	0.71	93.95
SPHOEROIDES PARVUS	1311	0.55	94.50
PRIACANTHUS ARENATUS	1254	0.52	95.02
ANCHOA LYOLEPIS	1219	0.51	95.53
SYNODUS FOETENS	1140	0.48	96.01
ARIOPSIS FELIS	1132	0.47	96.48
UPENEUS PARVUS	962	0.40	96.88
SELENE SETAPINNIS	659	0.27	97.16
POLYDACTYLUS OCTONEMUS	635	0.26	97.42
SYMPHURUS CIVITATUS	601	0.25	97.67
PEPRILUS PARU	596	0.25	97.92
CITHARICHTHYS SPILOPTERUS	595	0.25	98.17
LARIMUS FASCIATUS	378	0.16	98.33
LUTJANUS CAMPECHANUS	373	0.16	98.48
OGCOCEPHALUS SP.	342	0.14	98.63
ETRUMEUS TERES	289	0.12	98.75
OPISTHONEMA OGLINUM	287	0.12	98.87
MENTICIRRHUS AMERICANUS	216	0.09	98.96
UROPHYCIS FLORIDANUS	211	0.09	99.04
ORTHOPRISTIS CHRYSOPTERA	167	0.07	99.11
GYMNACHIRUS TEXAE	150	0.06	99.18
PRIONOTUS TRIBULUS	146	0.06	99.24
CHAETODIPTERUS FABER	131	0.05	99.29
BOLLMANNIA COMMUNIS	130	0.05	99.35
PRIONOTUS SALMONICOLOR	127	0.05	99.40
LUTJANUS SYNAGRIS	125	0.05	99.45
LAGODON RHOMBOIDES	75	0.03	99.48
SPHYRAENA GUACHANCHO	71	0.03	99.51
ENGRAULIS EURYSTOLE	70	0.03	99.54
SERRANICULUS PUMULIO	70	0.03	99.57
ANCHOA MITCHILLI	66	0.03	99.60
BREGMACEROS ATLANTICUS	64	0.03	99.62
SCOMBEROMORUS CAVALLA	62	0.03	99.65
LAGOCEPHALUS LAEVIGATUS	57	0.02	99.67

Table 4-19. (Continued).

ANCYLOPSETTA QUADROCELLATA	54	0.02	99.70
SARDINELLA AURITA	49	0.02	99.72
RHIZOPRIONODON TERRAENOVAE	48	0.02	99.74
CYCLOPSETTA CHITTENDENI	46	0.02	99.76
PARALICHTHYS LETHOSTIGMA	38	0.02	99.77
BREVOORTIA PATRONUS	38	0.02	99.79
SCORPAENA CALCARATA	37	0.02	99.80
SYMPHURUS PLAGIUSA	36	0.02	99.82
UROPHYCIS CIRRATUS	31	0.01	99.83
CARANX CRYSOS	29	0.01	99.84
OPHIDION WELSHI	27	0.01	99.85
BROTULA BARBATA	27	0.01	99.87
BALISTES CAPRISCUS	25	0.01	99.88
CARANX HIPPOS	21	0.01	99.88
PRIONOTUS OPHRYAS	20	0.01	99.89
SCOMBEROMORUS MACULATUS	19	0.01	99.90
SERRANUS SUBLIGARIUS	18	0.01	99.91
PARALICHTHYS ALBIGUTTA	15	0.01	99.91
HEMICARANX AMBLYRHYNCHUS	14	0.01	99.92
SPHYRNA TIBURO	14	0.01	99.93
GYMNOTHORAX NIGROMARGINATU	12	0.01	99.93
RAJA TEXANA	12	0.01	99.94
PRIONOTUS SCITULUS	12	0.01	99.94
ARCHOSARGUS PROBATOCEPHALU	11	0.00	99.95
MULLUS AURATUS	10	0.00	99.95
ENGYOPHRYS SENTA	9	0.00	99.95
RYPTICUS MACULATUS	8	0.00	99.96
SELENE VOMER	6	0.00	99.96
EUCINOSTOMUS ARGENTEUS	6	0.00	99.96
STEPHANOLEPIS HISPIDUS	6	0.00	99.96
SPHOEROIDES DORSALIS	5	0.00	99.97
OPHIDION GRAYI	5	0.00	99.97
EUCINOSTOMUS GULA	5	0.00	99.97
CARCHARHINUS BREVIPINNA	4	0.00	99.97
EPINEPHELUS NIVEATUS	4	0.00	99.97
GOBIONELLUS HASTATUS	3	0.00	99.98
HIPPOCAMPUS ERECTUS	3	0.00	99.98
SYMPHURUS UROSPILUS	3	0.00	99.98
OPHICHTHUS GOMESI	3	0.00	99.98
SYNGNATHUS LOUISIANAE	3	0.00	99.98
PRIONOTUS PARALATUS	3	0.00	99.98
ECHENEIS NAUCRATES	3	0.00	99.98
HEMIRHAMPHUS BRASILIENSIS	3	0.00	99.98
RACHYCENTRON CANADUM	3	0.00	99.99
BAGRE MARINUS	2	0.00	99.99
HILDEBRANDIA FLAVA	2	0.00	99.99
CITHARICHTHYS MACROPS	2	0.00	99.99
SYMPHURUS DIOMEDIANUS	2	0.00	99.99
POMATOMUS SALTATOR	2	0.00	99.99
OPISTOGNATHUS SP.	2	0.00	99.99
OASYATIS AMERICANUS	2	0.00	99.99
POGONIAS CROMIS	2	0.00	99.99
ECHIOPSIS PUNCTIFER	1	0.00	99.99
OPHIDION HOLBROOKI	1	0.00	99.99
CARCHARHINUS ACRONOTUS	1	0.00	99.99
SCIAENOPS OCELLATA	1	0.00	99.99
STEPHANOLEPIS SETIFER	1	0.00	99.99
CHILOMYCTERUS SCHOEPFI	1	0.00	99.99
DECAPTERUS PUNCTATUS	1	0.00	100.00
ASTROSCOPUS Y-GRAECUM	1	0.00	100.00
SPHYRNA LEWINI	1	0.00	100.00
OLIGOPLITES SAURUS	1	0.00	100.00
PRIONOTUS ROSEUS	1	0.00	100.00
PRIONOTUS STEARNSI	1	0.00	100.00
SCOMBER JAPONICUS	1	0.00	100.00

Table 4-19. (Continued).

DASYATIS SAYI	1	0.00	100.00
TRACHINOTUS CAROLINUS	1	0.00	100.00
MUGIL CEPHALUS	1	0.00	100.00
TOTAL	239680		

less important and made up 14% and 6% of the catch respectively.

Only nine species made up 82% of the ichthyofauna near the diffuser while 113 less abundant species made up the remaining 18%. Chloroscombrus chrysurus (30%) dominated the catch near the diffuser, closely followed by Cynoscion nothus (21%). Other abundant species included Peprilus burti (9%), Syacium gunteri (6%), Cynoscion arenarius (5%), Stenotomus caprinus (3%), Anchoa hepsetus (3%), Prionotus rubio (3%), and Trachurus lathami (2%).

4.11.1 Section Discussion

The composition of nekton in the diffuser area clearly reflects ecological transition between faunas of the inshore white and offshore brown shrimp communities, a pattern supported by cluster analysis to delineate station groupings. Both P. aztecus and P. setiferus (winter only) were common in the diffuser area, although previous analyses of white shrimp life history (Hann et al. 1979) indicated that the diffuser area was near the bathymetric limit for P. setiferus. The ichthyofauna of the diffuser area reflects typical members of the white shrimp community (such as Cynoscion nothus and C. arenarius) and of the brown shrimp community (such as Syacium gunteri and Stenotomus caprinus). The ichthyofauna near the diffuser also was characterized by an abundance of pelagic forms (Chloroscombrus chrysurus, Trachurus lathami, Peprilus burti) that are widespread in the white and brown shrimp communities.

Previous detailed analyses of the life histories of nekton species (Hann et al. 1979) also indicate that the diffuser area is in an ecological transition zone between the white and brown shrimp communities. Although seasonal movements occur, many species showed decreased abundance offshore of station 9 or the diffuser area including Penaeus setiferus, Micropogonias

undulatus, Cynoscion nothus, Cynoscion arenarius, Menticirrhus americanus, Stellifer lanceolatus, Ariopsis felis, Polydactylus octonemus and Trichiurus lepturus. Stenotomus caprinus, the dominant species of the brown shrimp community, however, showed low abundance near the diffuser compared to its great abundance offshore. Analysis of by station species percentage composition (Section 4.13) also supports the conclusion that the diffuser area lies in an ecological transition zone.

4.12 Diel Variation in Compositions of the Penaeid Shrimp and Ichthyofauna in the Diffuser Area

Compositions of the ichthyofauna and Penaeid shrimp in the defined diffuser area varied between day and night. The present section describes pooled compositions of the ichthyofauna and Penaeid shrimp at night during the period October 1978-February 1980 (Tables 4-20, 4-21) and during the day in the period July 1978-February 1980 (Tables 4-20, 4-22).

A total of 8,747 Penaeid shrimp were counted during night cruises and 2,277 were counted during the day cruises (Table 4-20). Penaeus aztecus was the dominant shrimp, making up 82% of the catch at night and 77% during the day. Penaeus setiferus made up 22% of the catch at night but only 11% during the day. Penaeus duorarum was only captured at night, when it made up 7% of the catch.

A total of 85,508 fishes of 105 species were counted during the night cruises (Table 4-21). Ten abundant species made up 84% of the catch at night, while 95 less abundant species made up the remaining 16%. Cynoscion nothus (33%) dominated the ichthyofauna at night. Other abundant species included Syacium gunteri (12%), Stenotomus caprinus (9%), Cynoscion arenarius (8%), Prionotus rubio (6%), Diplectrum bivittatum (5%), Porichthys

Table 4-20. Composition of Penaeid shrimp catches in the diffuser area during day cruises (July 1978-February 1980) and during night cruises (October 1978-February 1980).

Day Cruises

Species	Total Catch	Mean Catch	%
Penaeus aztecus	1748	6.15	76.77
Penaeus setiferus	511	1.80	22.44
Penaeus duorarum	18	0.06	0.79
Number of tows	284		
Total	2277		

Night Cruises

Species	Total Catch	Mean Catch	%
Penaeus aztecus	7144	28.02	81.67
Penaeus setiferus	977	3.83	11.17
Penaeus duorarum	626	2.45	7.16
Number of tows	255		
Total	8747		

Table 4-21. Composition of dominant and non-dominant species of fish. Diffuser area. All night cruises.

Dominant Species (10)	Total Catch	Mean Catch	%	Cum. %
CYNOSCION NOTHUS	28214	110.64	33.00	33.00
SYACIUM GUNTERI	10294	40.37	12.04	45.03
STENOTOMUS CAPRINUS	7701	30.20	9.01	54.04
CYNOSCION ARENARIUS	7039	27.60	8.23	62.27
PRIONOTUS RUBIO	5547	21.75	6.49	68.76
DIPLECTRUM BIVITTATUM	4268	16.74	4.99	73.75
PORICHTHYS POROSISSIMUS	2976	11.67	3.48	77.23
HALIEUTICHTHYS ACULEATUS	2452	9.62	2.87	80.10
CHLOROSCOMBRUS CHRYSURUS	1858	7.29	2.17	82.27
LEPOPHIDIUM GRAELLSI	1822	7.15	2.13	84.40
Non-Dominant Species (95)				
CENTROPRISTIS PHILADELPHIC	1528	5.99	1.79	86.19
ETROPUS CROSSOTUS	1380	5.41	1.61	87.80
PRIACANTHUS ARENATUS	1226	4.81	1.43	89.24
PEPRILUS BURTI	1051	4.12	1.23	90.47
SPHOEROIDES PARVUS	985	3.86	1.15	91.62
SAURIDA BRASILIENSIS	692	2.71	0.81	92.43
SYNODUS FOETENS	627	2.46	0.73	93.16
UPENEUS PARVUS	592	2.32	0.69	93.85
SYMPHURUS CIVITATUS	581	2.28	0.68	94.53
MICROPOGONIAS UNDULATUS	541	2.12	0.63	95.17
CITHARICHTHYS SPILOPTERUS	524	2.05	0.61	95.78
ARIOPSIS FELIS	461	1.81	0.54	96.32
LEIOSTOMUS XANTHURUS	254	1.00	0.30	96.61
LUTJANUS CAMPECHANUS	228	0.89	0.27	96.88
UROPHYCIS FLORIDANUS	193	0.76	0.23	97.11
OGCOCEPHALUS DECLIVIROSTRI	184	0.72	0.22	97.32
TRICHIURUS LEPTURUS	161	0.63	0.19	97.51
GYMNACHIRUS TEXAE	131	0.51	0.15	97.66
MENTICIRRHUS AMERICANUS	131	0.51	0.15	97.82
BOLLMANNIA COMMUNIS	124	0.49	0.15	97.96
ANCHOA HEPSETUS	123	0.48	0.14	98.11
PRIONOTUS TRIBULUS	123	0.48	0.14	98.25
POLYDACTYLUS OCTONEMUS	117	0.46	0.14	98.39
PRIONOTUS SALMONICOLOR	113	0.44	0.13	98.52
OGCOCEPHALUS PANTOSTICTUS	103	0.40	0.12	98.64
LUTJANUS SYNAGRIS	91	0.36	0.11	98.74
ANCHOA LYOLEPIS	83	0.33	0.10	98.84
PEPRILUS PARU	67	0.26	0.08	98.92
BREGMACEROS ATLANTICUS	64	0.25	0.07	99.00
SERRANICULUS PUMULIO	64	0.25	0.07	99.07
SELENE SETAPINNIS	62	0.24	0.07	99.14
LARIMUS FASCIATUS	61	0.24	0.07	99.21
ORTHOPRISTIS CHRYSOPTERA	60	0.24	0.07	99.28
ANCHOA MITCHILLI	52	0.20	0.06	99.34
SYMPHURUS PLAGIUSA	35	0.14	0.04	99.39
BREVOORTIA PATRONUS	33	0.13	0.04	99.42
SCORPAENA CALCARATA	33	0.13	0.04	99.46
CYCLOPSETTA CHITTENDENI	33	0.13	0.04	99.50
UROPHYCIS CIRRATUS	30	0.12	0.04	99.54
ANCYLOPSETTA QUADROCELLATA	30	0.12	0.04	99.57
TRACHURUS LATHAMI	26	0.10	0.03	99.60
BROTULA BARBATA	26	0.10	0.03	99.63
OPHIDION WELSHI	25	0.10	0.03	99.66

Table 4-21. (Continued).

PARALICHTHYS LETHOSTIGMA	24	0.09	0.03	99.69
CHAETODIPTERUS FABER	22	0.09	0.03	99.72
LAGOCEPHALUS LAEVIGATUS	21	0.08	0.02	99.74
SERRANUS SUBLIGARIUS	18	0.07	0.02	99.76
PRIONOTUS OPHRYAS	12	0.05	0.01	99.78
GYMNOTHORAX NIGROMARGINATU	11	0.04	0.01	99.79
OPISTHONEMA OGLINUM	11	0.04	0.01	99.80
ETRUMEUS TERES	11	0.04	0.01	99.81
PRIONOTUS SCITULUS	10	0.04	0.01	99.83
MULLUS AURATUS	10	0.04	0.01	99.84
ARCHOSARGUS PROBATOCEPHALU	9	0.04	0.01	99.85
LAGODON RHOMBOIDES	8	0.03	0.01	99.86
SCOMBEROMORUS MACULATUS	8	0.03	0.01	99.87
RYPTICUS MACULATUS	8	0.03	0.01	99.88
ENGYOPHRYS SENTA	8	0.03	0.01	99.88
RAJA TEXANA	7	0.03	0.01	99.89
STEPHANOLEPIS HISPIDUS	6	0.02	0.01	99.90
SPHYRNA TIBURO	6	0.02	0.01	99.91
OPHIDION GRAYI	5	0.02	0.01	99.91
SARDINELLA AURITA	5	0.02	0.01	99.92
BALISTES CAPRISCUS	4	0.02	0.00	99.92
PARALICHTHYS ALBIGUTTA	4	0.02	0.00	99.93
HARENGULA JAGUANA	4	0.02	0.00	99.93
CARCHARHINUS BREVIPINNA	4	0.02	0.00	99.94
SPHYRAENA GUACHANCHO	3	0.01	0.00	99.94
SYNGNATHUS LOUISIANAE	3	0.01	0.00	99.94
EUCINOSTOMUS ARGENTEUS	3	0.01	0.00	99.95
ENGRAULIS EURYSTOLE	3	0.01	0.00	99.95
EUCINOSTOMUS GULA	3	0.01	0.00	99.95
GOBIONELLUS HASTATUS	3	0.01	0.00	99.96
SYMPHURUS UROSPILUS	3	0.01	0.00	99.96
HIPPOCAMPUS ERECTUS	3	0.01	0.00	99.97
HEMIRHAMPHUS BRASILIENSIS	3	0.01	0.00	99.97
EPINEPHELUS NIVEATUS	3	0.01	0.00	99.97
CITHARICHTHYS MACROPS	2	0.01	0.00	99.97
OPHICHTHUS GOMESI	2	0.01	0.00	99.98
HILDEBRANDIA FLAVA	2	0.01	0.00	99.98
OPISTOGNATHUS SP.	2	0.01	0.00	99.98
SYMPHURUS DIOMEDIANUS	2	0.01	0.00	99.98
STEPHANOLEPIS SETIFER	1	0.00	0.00	99.99
OPHIDION HOLBROOKI	1	0.00	0.00	99.99
MUGIL CEPHALUS	1	0.00	0.00	99.99
PRIONOTUS ROSEUS	1	0.00	0.00	99.99
RACHYCENTRON CANADUM	1	0.00	0.00	99.99
SELENE VOMER	1	0.00	0.00	99.99
OLIGOPLITES SAURUS	1	0.00	0.00	99.99
ECHIOPSIS PUNCTIFER	1	0.00	0.00	99.99
SCOMBER JAPONICUS	1	0.00	0.00	99.99
HEMICARANX AMBLYRHYNCHUS	1	0.00	0.00	100.00
ASTROSCOPUS Y-GRAECUM	1	0.00	0.00	100.00
CHILOMYCTERUS SCHOEPFI	1	0.00	0.00	100.00
CARANX CRYSOS	1	0.00	0.00	100.00
NUMBER OF TOWS	255			
TOTAL	85508			

Table 4-22. Composition of dominant and non-dominant species of fish. Diffuser area. All day cruises.

Dominant Species (7)	Total Catch	Mean Catch	%	Cum. %
CHLOROSCOMBRUS CHRYSURUS	71584	252.06	46.05	46.05
CYNOSCION NOTHUS	21304	75.01	13.70	59.75
PEPRILUS BURTI	19857	69.92	12.77	72.53
ANCHOA HEPSETUS	7264	25.58	4.67	77.20
TRACHURUS LATHAMI	5520	19.44	3.55	80.75
SYACIUM GUNTERI	5045	17.76	3.25	84.00
CYNOSCION ARENARIUS	3919	13.80	2.52	86.52
Non-Dominant Species (90)				
LEIOSTOMUS XANTHURUS	2746	9.67	1.77	88.28
MICROPOGONIAS UNDULATUS	2739	9.64	1.76	90.05
TRICHIURUS LEPTURUS	2299	8.10	1.48	91.53
HARENGULA JAGUANA	1707	6.01	1.10	92.62
PRIONOTUS RUBIO	1330	4.68	0.86	93.48
ANCHOA LYOLEPIS	1136	4.00	0.73	94.21
SAURIDA BRASILIENSIS	1072	3.77	0.69	94.90
ARIOPSIS FELIS	671	2.36	0.43	95.33
SELENE SETAPINNIS	597	2.10	0.38	95.71
PEPRILUS PARU	529	1.86	0.34	96.06
DIPLECTRUM BIVITTATUM	519	1.83	0.33	96.39
POLYDACTYLUS OCTONEMUS	518	1.82	0.33	96.72
SYNODUS FOETENS	513	1.81	0.33	97.05
ETROPUS CROSSOTUS	491	1.73	0.32	97.37
CENTROPRISTIS PHILADELPHIC	447	1.57	0.29	97.66
UPENEUS PARVUS	370	1.30	0.24	97.89
SPHOEROIDES PARVUS	331	1.17	0.21	98.11
LARIMUS FASCIATUS	317	1.12	0.20	98.31
ETRUMEUS TERES	278	0.98	0.18	98.49
OPISTHONEMA OGLINUM	276	0.97	0.18	98.67
PORICHTHYS POROSISSIMUS	251	0.88	0.16	98.83
HALIEUTICHTHYS ACULEATUS	213	0.75	0.14	98.97
STENOTOMUS CAPRINUS	203	0.71	0.13	99.10
LUTJANUS CAMPECHANUS	145	0.51	0.09	99.19
CHAETODIPTERUS FABER	109	0.38	0.07	99.26
ORTHOPRISTIS CHRYSOPTERA	107	0.38	0.07	99.33
MENTICIRRHUS AMERICANUS	85	0.30	0.05	99.38
CITHARICHTHYS SPILOPTERUS	71	0.25	0.05	99.43
SPHYRAENA GUACHANCHO	68	0.24	0.04	99.47
ENGRAULIS EURYSTOLE	67	0.24	0.04	99.52
LAGODON RHOMBOIDES	67	0.24	0.04	99.56
SCOMBEROMORUS CAVALLA	62	0.22	0.04	99.60
RHIZOPRIONODON TERRAENOVAE	48	0.17	0.03	99.63
SARDINELLA AURITA	44	0.15	0.03	99.66
OGCOCEPHALUS DECLIVIROSTRI	43	0.15	0.03	99.69
LAGOCEPHALUS LAEVIGATUS	36	0.13	0.02	99.71
LUTJANUS SYNAGRIS	34	0.12	0.02	99.73
CARANX CRYSOS	28	0.10	0.02	99.75
PRIACANTHUS ARENATUS	28	0.10	0.02	99.77
LEPOPHIDIUM GRAELLSI	26	0.09	0.02	99.78
ANCYLOPSETTA QUADROCELLATA	24	0.08	0.02	99.80
PRIONOTUS TRIBULUS	23	0.08	0.01	99.81
CARANX HIPPOS	21	0.07	0.01	99.83
BALISTES CAPRISCUS	21	0.07	0.01	99.84
SYMPHURUS CIVITATUS	20	0.07	0.01	99.85
GYMNACHIRUS TEXAE	19	0.07	0.01	99.87

Table 4-22. (Continued).

UROPHYCIS FLORIDANUS	18	0.06	0.01	99.88
ANCHOA MITCHILLI	14	0.05	0.01	99.89
PRIONOTUS SALMONICOLOR	14	0.05	0.01	99.89
PARALICHTHYS LETHOSTIGMA	14	0.05	0.01	99.90
CYCLOPSETTA CHITTENDENI	13	0.05	0.01	99.91
HEMICARANX AMBLYRHYNCHUS	13	0.05	0.01	99.92
OGCOCEPHALUS PANTOSTICTUS	12	0.04	0.01	99.93
PARALICHTHYS ALBIGUTTA	11	0.04	0.01	99.94
SCOMBEROMORUS MACULATUS	11	0.04	0.01	99.94
PRIONOTUS OPHRYAS	8	0.03	0.01	99.95
SPHYRNA TIBURO	8	0.03	0.01	99.95
BOLLMANNIA COMMUNIS	6	0.02	0.00	99.96
SERRANICULUS PUMULIO	6	0.02	0.00	99.96
RAJA TEXANA	5	0.02	0.00	99.96
SELENE VOMER	5	0.02	0.00	99.97
BREVOORTIA PATRONUS	5	0.02	0.00	99.97
SCORPAENA CALCARATA	4	0.01	0.00	99.97
PRIONOTUS PARALATUS	3	0.01	0.00	99.97
EUCINOSTOMUS ARGENTEUS	3	0.01	0.00	99.98
ECHENEIS NAUCRATES	3	0.01	0.00	99.98
OPHIDION WELSHI	2	0.01	0.00	99.98
PRIONOTUS SCITULUS	2	0.01	0.00	99.98
EUCINOSTOMUS GULA	2	0.01	0.00	99.98
POMATOMUS SALTATOR	2	0.01	0.00	99.98
ARCHOSARGUS PROBATOCEPHALU	2	0.01	0.00	99.98
POGONIAS CROMIS	2	0.01	0.00	99.99
DASYATIS AMERICANUS	2	0.01	0.00	99.99
BAGRE MARINUS	2	0.01	0.00	99.99
RACHYCENTRON CANADUM	2	0.01	0.00	99.99
SYMPHURUS PLAGIUSA	1	0.00	0.00	99.99
SPHYRNA LEWINI	1	0.00	0.00	99.99
SCIAENOPS OCELLATA	1	0.00	0.00	99.99
EPINEPHELUS NIVEATUS	1	0.00	0.00	99.99
CARCHARHINUS ACRONOTUS	1	0.00	0.00	99.99
DASYATIS SAYI	1	0.00	0.00	99.99
ALUTERUS SCHOEPFI	1	0.00	0.00	99.99
TRACHINOTUS CAROLINUS	1	0.00	0.00	99.99
PRIONOTUS STEARNSI	1	0.00	0.00	100.00
GYMNOTHORAX NIGROMARGINATU	1	0.00	0.00	100.00
BROTULA BARBATA	1	0.00	0.00	100.00
OPHICHTHUS GOMESI	1	0.00	0.00	100.00
UROPHYCIS CIRRATUS	1	0.00	0.00	100.00
ENGYOPHRYS SENTA	1	0.00	0.00	100.00
DECAPTERUS PUNCTATUS	1	0.00	0.00	100.00
NUMBER OF TOWS	284			
TOTAL	155451			

porosissimus (3%), Halieutichthys aculeatus (3%), Chloroscombrus chrysurus (2%), and Lepophidium graellsi (2%).

A total of 155,451 fishes of 97 species were counted during day cruises (Table 4-22). Seven abundant species made up 87% of the catch during the day, while 90 less abundant species made up the remaining 13%. Chloroscombrus chrysurus (46%) dominated the catch in the day. Other abundant species included Cynoscion nothus (14%), Peprilus burti (13%), Anchoa hepsetus (5%), Trachurus lathami (4%), Syacium gunteri (3%), and Cynoscion arenarius (3%).

4.12.1 Section Discussion

Diel patterns in Penaeid shrimp and fish compositions in the diffuser area generally were similar to those described in Section 4.4. The Penaeid shrimp exhibited the generally recognized pattern that Penaeus aztecus and P. duorarum were more prominent at night than during the day. However, P. setiferus was most prominent at night in the diffuser area. As noted in Section 4.4 Cynoscion nothus and Porichthys porosissimus were most important at night while pelagic fishes such as Chloroscombrus chrysurus, Peprilus burti, Anchoa hepsetus and Trachurus lathami became more important during the day.

4.13 Compositions by Station of the Penaeid Shrimp Fauna and Ichthyofauna in the Diffuser Area

Compositions of the Penaeid shrimp and the principal ichthyofauna in the diffuser area are presented in this section by station (Table 4-23) to illustrate the among station faunal homogeneity in this area. Compositions at stations 9, 10, and 26 are presented for comparison, because

Table 4-23. Percentage compositions by station of the Penaeid shrimp and principal ichthyofauna in the diffuser area, October 1977-February 1980. Stations 9, 26,and 10 are included for comparison.

	Station						
Species	14	15	16	17	18	19	20
Penaeus aztecus	82.39	85.05	79.14	78.23	86.57	79.25	77.11
Penaeus setiferus	7.42	9.75	15.06	19.15	7.07	17.23	16.12
Penaeus duorarum	10.20	5.21	5.80	2.63	6.36	3.52	6.78
Chloroscombrus chrysurus	35.31	26.35	33.69	24.35	21.69	34.25	24.24
Cynoscion nothus	13.42	21.76	11.99	18.17	22.44	15.84	21.56
Peprilus burti	4.42	3.63	6.09	7.10	13.32	10.37	18.21
Syacium gunteri	4.75	8.54	7.67	6.07	7.03	7.02	5.31
Cynoscion arenarius	3.06	3.79	3.62	3.46	3.58	4.36	7.58
Stentomus caprinus	1.53	1.62	3.81	3.81	2.53	2.82	2.72
Anchoa hepsetus	6.56	8.39	8.74	3.41	1.18	1.47	1.15
Prionotus rubio	1.68	3.13	2.57	2.65	4.53	3.34	3.38
Trachurus lathami	8.34	2.64	2.30	2.71	0.61	0.82	1.32
Diplectrum bivitattum	1.76	3.31	2.58	1.57	1.80	1.85	1.49
Porichthys porosissimus	1.11	2.11	2.71	1.29	1.52	2.30	0.88

(continued)

Table 4-23 (continued).

Species	Station 21	22	23	24	25	Range of percentages in the defined Diffuser area
Penaeus aztecus	74.84	81.12	83.11	83.69	79.13	75-86
Penaeus setiferus	17.37	14.98	9.76	11.89	15.89	7-19
Penaeus duorarum	7.79	3.90	7.12	4.42	4.98	3-10
Chloroscombrus chrysurus	35.70	25.00	33.88	33.64	21.88	22-36
Cynoscion nothus	19.45	18.74	24.43	27.52	37.82	12-28
Peprilus burti	7.43	22.75	2.62	6.07	6.29	4-23
Syacium gunteri	5.24	5.00	7.01	7.13	6.90	5- 9
Cynoscion arenarius	7.84	7.57	4.93	2.68	3.62	3- 8
Stenetomus caprinus	3.42	3.41	3.03	5.01	6.31	2- 6
Anchoa hepsetus	0.48	0.76	0.67	0.66	0.71	1- 9
Prionotus rubio	3.92	2.72	3.15	2.29	2.14	2- 5
Trachurus lathami	1.66	0.65	0.94	0.34	0.96	1- 8
Diplectrum bivitattum	1.66	1.64	1.96	2.24	2.34	2- 3
Porichthys porosissimus	0.94	0.70	1.19	0.81	0.79	1- 3

(continued)

Table 4-23 (continued).

Species	Station 9	26	10
Penaeus aztecus	66.52	91.42	94.14
Penaeus setiferus	17.80	4.42	5.05
Penaeus duorarum	15.67	4.16	0.81
Chloroscombrus chrysurus	23.39	16.52	22.34
Cynoscion nothus	25.18	5.63	0.59
Peprilus burti	5.95	13.14	2.95
Syacium gunteri	3.79	15.37	20.86
Cynoscion arenarius	5.49	9.69	2 81
Stenetomus caprinus	2.58	3.45	5.31
Anchoa hepsetus	1.23	2.06	1.62
Prionotus rubio	2.15	3.76	4.35
Trachurus lathami	5.83	1.29	6.93
Diplectrum bivitattum	0.98	7.03	12.45
Porichthys porosissimus	1.11	1.60	1.14

cluster analysis (Section 4.5) indicated that these stations could also be included with the diffuser area.

Station by station nekton compositions in the defined diffuser area generally were very similar, as expected, and agree with the results of the cluster analysis that stations in the defined diffuser area formed a basically homogeneous set. The pelagic fishes Chloroscombrus chrysurus, Peprilus burti, Anchoa hepsetus, and Trachurus lathami, showed greatest between station variation in percentage compositions as would be expected from their strongly schooling behavior and movements.

Percentages of certain especially important fauna at stations 9, 10, and 26 were at or outside the extreme values of percentage composition ranges for stations in the defined diffuser area. In comparison to the defined diffuser area, generally: 1) Penaeus aztecus was less important at station 9 and more important at stations 10 and 26, 2) Penaeus setiferus was more important at station 9 and less important at stations 10 and 26, 3) Cynoscion nothus was more important at station 9 and less important at stations 10 and 26, and 4) Syacium gunteri was less important at station 9 and more important at stations 10 and 26. These faunal differences of stations 9, 10, and 26 from the defined diffuser area involve important species, basically reflect the transitional nature of the fauna in that area, and support the exclusion--in so far as it remains feasible--of stations 9, 10, and 26 from the defined diffuser area.

4.14 Seasonal and Monthly Compositions of the Penaeid Shrimp Fauna and Ichthyofauna in the Diffuser Area

Compositions of the Penaeid shrimp fauna and the ichthyofauna each showed seasonal and monthly patterns in the defined diffuser area. The

present section describes seasonal trends in that area (Tables 4-14-4-18). Monthly compositions of the abundant fishes and penaeid shrimp are presented in Appendix Tables 7-8-7-19, but they are not specifically discussed. However, these monthly tables include important information of use in preplanning stages to select principal fauna whose among stations attributes might be studied in detail in given short intensive postdisposal periods.

Penaeus aztecus was the dominant shrimp in the diffuser area during the spring, summer and fall, reaching maximum abundance in the fall and spring (Table 4-18). Penaeus setiferus was more important than P. aztecus during the winter, although P. aztecus remained very important. Penaeus duorarum was most important in the winter and spring but never made up a major part of the catch.

The dominant ichthyofauna showed distinct seasonal trends in the diffuser area. During summer, the dominant taxa included members of the Engraulidae (Anchoa hepsetus), Ophidiidae (Lepophidium graellsi), Carangidae (Chloroscombrus chrysurus and Trachurus lathami) and Triglidae (Prionotus rubio). Compositions of the dominant fauna changed in the fall. Lepophidium graellsi and Prionotus rubio decreased in importance while Anchoa hepsetus, Chloroscombrus chrysurus, and Trachurus lathami continued dominant. Taxa that assumed a dominant position during fall included members of the Synodontidae (Saurida brasiliensis), Batrachoididae (Porichthys porosissimus), Ogcocephalidae(Halieutichthys aculeatus), Sciaenidae (Cynoscion nothus), Bothidae (Syacium gunteri), and Stromateidae (Peprilus burti). As winter commenced, compositions of the dominant fauna continued to change. Anchoa hepsetus, Saurida brasiliensis, Porichthys porosissimus, Halieutichthys aculeatus, Chloroscombrus chrysurus, and Trachurus lathami decreased in importance, but Cynoscion nothus, Peprilus burti, and Syacium gunteri

continued dominant. No taxa assumed a dominant role during winter in the diffuser area in contrast to the pattern in the inshore and offshore areas. As spring began, compositions of the dominant fauna changed only slightly in the diffuser area. Diplectrum bivittatum, Cynoscion arenarius, and Prionotus rubio assumed or resumed dominance in the spring. Several taxa continued their dominant position in the spring including Cynoscion nothus, Peprilus burti, and Syacium gunteri. No species lost a dominant position during spring in the diffuser area, again in contrast to the inshore and offshore areas. As summer began, compositions of the dominant fauna again changed in the diffuser area. Anchoa hepsetus, Lepophidium graellsi and Trachurus lathami assumed a dominant position while Chloroscombrus chrysurus and Prionotus rubio continued dominant. Several species lost a dominant position during summer including Diplectrum bivittatum, Cynoscion arenarius, C. nothus, Peprilus burti, and Syacium gunteri.

4.14.1 Section Discussion

The diffuser area lies in a transition zone between the inshore white shrimp community and the offshore brown shrimp community as described in Section 4.5. The diffuser area fauna includes elements of these two communities. The transitional nature of the community in the diffuser area is in part due to season-related inshore-offshore movements of the nekton. Section 4.8.3 discusses such movements in more detail and integrates findings from analysis of the inshore, offshore, and diffuser areas

4.15 Monthly and Among Stations Trends in Total Shrimp Abundance in the Diffuser Area

Monthly trends and among stations trends in total shrimp abundance

are described in this section based on results of two-way analysis of variance (Tables 4-24, 4-25) and multiple range tests (Tables 4-26 - 4-29), procedures which were described in detail in Section 4.2.3. A general overview of the results of significance tests is presented in Section 4.15.1 followed by an examination of among stations differences (4.15.2) and monthly trends (4.15.3). Interpretation of interaction is incorporated with the analysis of among stations differences.

4.15.1 General Overview of the Results of Significance Tests

Analysis of variance for the two night cruise x station sets and for the two day cruise x station sets found highly significant differences among cruise main effects in each F test, but among station main effects were not significant in three of the four F tests. Interaction was significant in three of the four F tests, which implies a complex situation in that among stations differences vary with time (e.g.--cruises) and are not consistent.

Among cruise variation was by far the most important source of variation in total shrimp abundance; variation due to interaction or among stations was comparatively unimportant. R-square values indicate that among cruise variation made up 87-88% of the total variation in night cruises (Table 4-24) and 64-70% in day cruises (Table 4-25). Interaction accounted for only 5-7% of the total variation (when significant) in night cruises but 18-20% in day cruises. The relative importance of among cruise and interaction variation differed between the day and the night cruise sets, but the reason for that is not clear. Among stations variation in total shrimp abundance was consistent in magnitude between day and night cruises but was always negligible and accounted for only 5% of the total variation in the one instance where it was significant.

Table 4-24. Summary of two-way analyses of variance for total abundance of shrimp in night cruises. See Section 4.2.3 for list of cruises included in each analysis set.

A. Experimental design: night cruises; diffuser stations 14, 17-25 inclusive

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	179	341.70	-	-	1.0000
Stations	9	1.07	.40	.9321	.0031
Cruises	8	296.07	124.42	.0001	.8665
Interaction	72	17.79	.83	.7925	.0521
Error	90	26.77	-	-	.0738

C. Experimental design: night cruises; diffuser stations 14, 15, 16, 17

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	55	87.80	-	-	1.0000
Stations	3	0.43	1.02	.3988	.0049
Cruises	6	77.41	92.78	.0001	.8817
Interaction	18	6.07	2.43	.0172	.0691
Error	28	3.89	-	-	.0443

Table 4-25. Summary of two-way analyses of variance for total abundance of shrimp in day cruises. See Section 4.2.3 for list of cruises included in each analysis set.

B. Experimental design: day cruises; diffuser stations 14, 17-25 inclusive

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	159	202.59	-	-	1.0000
Stations	9	9.63	3.19	.0025	.0475
Cruises	7	130.32	55.56	.0001	.6433
Interaction	63	35.83	1.70	.0128	.1769
Error	80	26.81	-	-	.1323

D. Experimental design: day cruises; diffuser stations 14, 15, 16, 17

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	63	90.89	-	-	1.0000
Stations	3	0.43	0.55	0.6549	.0047
Cruises	7	63.22	34.56	0.0001	.6956
Interaction	21	18.88	3.44	0.0008	.2077
Error	32	8.36	-	-	.0920

Table 4-26. Summary of Student-Newman-Keuls multiple range tests of total shrimp abundance between diffuser stations (14, 17-25 inclusive) in day cruises. Station main effects were significant at $\alpha = .003$. Means presented were antilogged after significance tests were made.

Grouping	Mean	Stations
a	6	25
ab	6	19
abc	5	20
abcd	5	24
abcd	5	17
abcd	5	23
abcd	4	22
abcd	4	18
abcd	3	21
d	3	14

25, 19, 20 > 14

Table 4-27. Summary of non-significant Student-Newman-Keuls multiple range tests of total shrimp abundance to examine interaction for station differences within cruises.

Stations 14, 17-25 inclusive		Stations 14, 15, 16, 17	
Night Cruises	Day Cruises	Night Cruises	Day Cruises
Neither Interaction nor Stations main effect significant	Feb., 79	Oct., 78	July, 78
	Aug., 79	Mar., 79	Oct., 78
	Oct., 79	Apr., 79	Dec., 78
	Nov., 79	May, 79	Feb., 79
	Dec., 79	June, 79	Apr., 79
	Jan., 80		Aug., 79
	Feb., 80		Oct., 79

Table 4-28. Summary of significant Student-Newman-Keuls multiple range tests of total shrimp abundance to examine interaction for station differences within cruises. All means, rounded to two decimal places, are based on two tows.

B. Experimental design: day cruises; diffuser stations 14, 17-25 inclusive

April, 79

Grouping	Mean	Station
a	2.05	20
a b	1.59	25
a b	1.39	24
a b	1.24	23
a b	1.15	19
a b	0.80	22
a b	0.69	21
a b	0.35	17
b	0.00	14
b	0.00	18

20 > 14, 18

D. Experimental design: day cruises; diffuser stations 14, 15, 16, 17

September, 78

Grouping	Mean	Station
a	3.39	14
a	2.96	16
a	2.91	15
b	0.35	17

14, 16, 15 > 17

C. Experimental design: night cruises; diffuser stations 14, 15, 16, 17

December, 78

Grouping	Mean	Station
a	4.33	15
a	4.17	14
b	3.35	16
b	3.16	17

15, 14 > 16, 17

July, 79

Grouping	Mean	Station
a	1.10	14
a b	0.35	16
b	0.00	15
b	0.00	17

14 > 15, 17 ; 16 > 17

Table 4-29. Summary of Student-Newman-Keuls multiple range tests of total shrimp abundance between cruises. Means presented were antilogged after significance tests were made.

Comparisons Based on Stations 14, 17-25 Inclusive

Night Cruises			Day Cruises		
Grouping	Mean	Cruise	Grouping	Mean	Cruise
a	116	Jun, 79	a	33	Oct, 79
b	64	Nov, 79	b	9	Nov, 79
c	29	Jan, 80	c	5	Jan, 80
c	24	Mar, 79	cd	4	Feb, 79
c	22	May, 79	de	3	Feb, 80
c	22	Oct, 79	def	3	Apr, 79
f	11	Apr, 79	ef	2	Aug, 79
g	5	Dec, 79	f	2	Dec, 79
h	1	Jul, 79			

Comparisons based on Stations 14, 15, 16, 17

Night Cruises			Day Cruises		
Grouping	Mean	Cruise	Grouping	Mean	Cruise
a	82	Jun, 79	a	18	Oct, 79
b	43	Dec, 78	ab	13	Dec, 78
c	25	Oct, 78	abc	11	Sep, 78
cd	24	Mar, 79	bcd	9	Jul, 78
cd	21	May, 79	f	4	Feb, 79
e	14	Apr, 79	f	3	Aug, 79
f	1	Jul, 79	g	1	Apr, 79
			g	1	Oct, 78

4.15.2 Among Stations Trends in Total Shrimp Abundance in the Diffuser Area

There were few significant differences among diffuser stations but no consistent pattern of differences was apparent.

Observed differences among overall station means (main effects) were very small within cruise sets (Figure 4-14) and generally were not significant. Overall abundance at station 14 was significantly lower than at stations 25, 19,and 20 but only in the day cruise set (Table 4-26); but this pattern was not consistent, appearing in only one of eight individual day cruises when interaction was examined (Tables 4-27, 4-28).

Among stations differences were significant in only 4 of the 32 cruise station cells examined (Tables 4-27, 4-28), but no pattern was consistent. Neither interaction nor station main effects were significant in the night cruise set where diffuser stations 14 and 17-25 inclusive were compared (Table 4-24). In three of these four instances of significance cited, total abundance of shrimp at station 17 was significantly lower than at some other stations or approached significance. Only two Penaeid shrimp were captured other than at station 14 in one of these instances (July 79, night), although all the diffuser stations were occupied, so that abundance at station 17 on that occasion equalled abundance at most other diffuser stations. That cruise occurred when dissolved oxygen was low (see Section 4,9) and the slightly higher catches of shrimp at station 14 might suggest locally higher dissolved oxygen. Abundance at stations 15 and 16, during both day and night, generally equalled or was not significantly different from stations 14 and 17 in the 15 cruise x station cells examined for this comparison (Tables 4-27, 4-28).

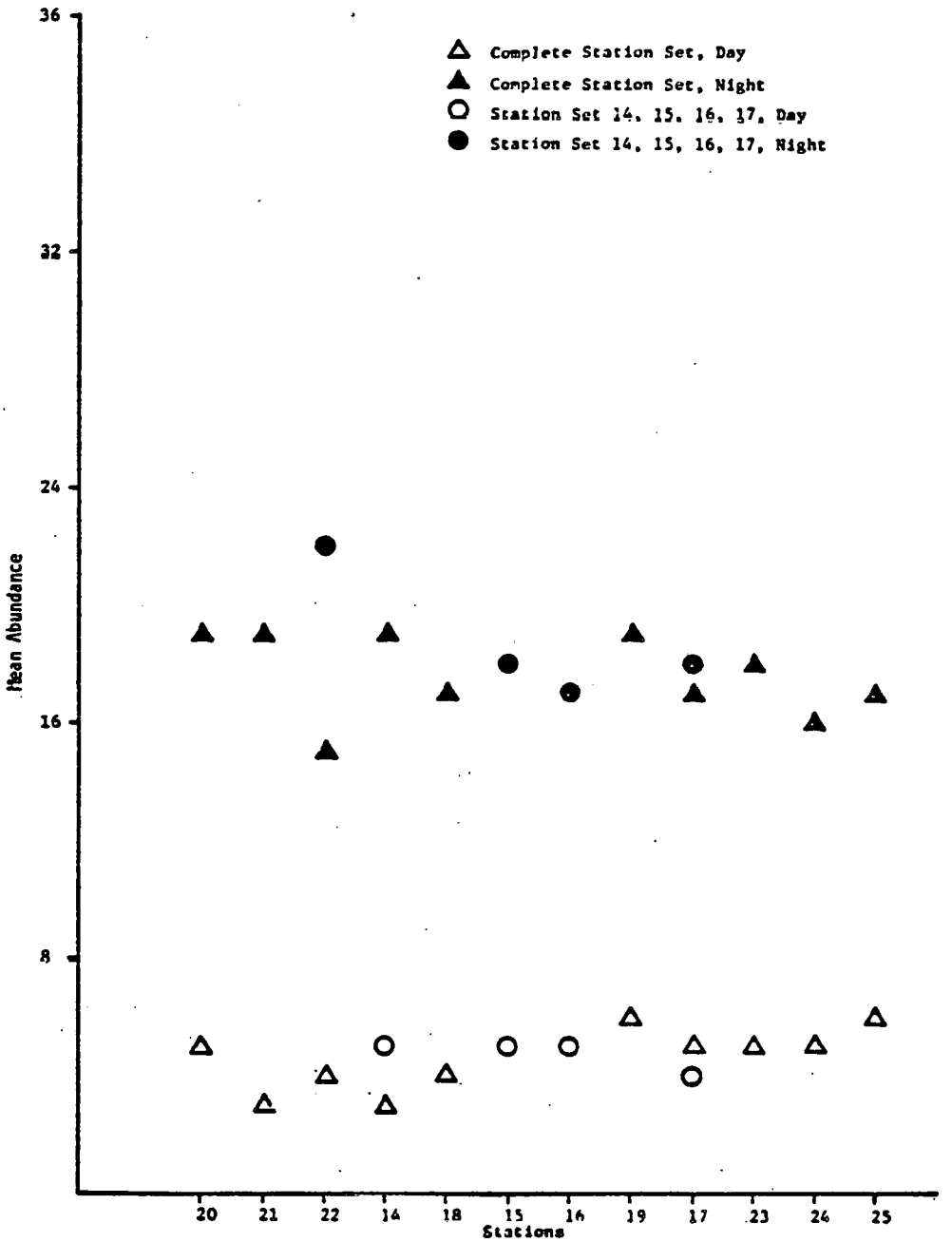

Figure 4-14. Geometric mean total abundance of shrimp by station in the diffuser area.

4.15.3 Monthly Trends in Total Shrimp Abundance in the Diffuser Area

Total abundance of shrimp each month, especially in 1979, showed trends and generally significant differences which apparently reflected movements of P. aztecus into the diffuser area (Figure 4-15, Table 4-29). Abundance in 1979 was markedly highest in June which is when P. aztecus enters the Gulf and when they reached the diffuser in abundance. Abundance sharply declined from June to July 1979, probably reflecting low oxygen conditions in that year, and remained low through August. Abundance thereafter increased from cruise to cruise in October and early November and then decreased in late November and December. Trends in Fall 1978 seemed similar to those in 1979 but were not as distinct.

4.15.4 Section Discussion

Although significant differences in total shrimp abundance were detected among the diffuser stations, they were small in magnitude, few in number, and formed no consistent pattern. Among stations variation, moreover, made up only a small part of the total variation. The few instances of significance found are often difficult to explain and probably largely reflect contagion and microspatial or microtemporal movements. Hann et al. (1979) plotted measures of variation in shrimp catches against mean abundance and concluded that contagion did occur. All in all, it appears that Penaeid shrimp were homogeneously distributed throughout the diffuser area in the predisposal period.

Monthly trends in the total abundance of Penaeid shrimp in the diffuser area were similar to those in the inshore area, and among cruise variation was by far the most important factor in the total variation of total shrimp

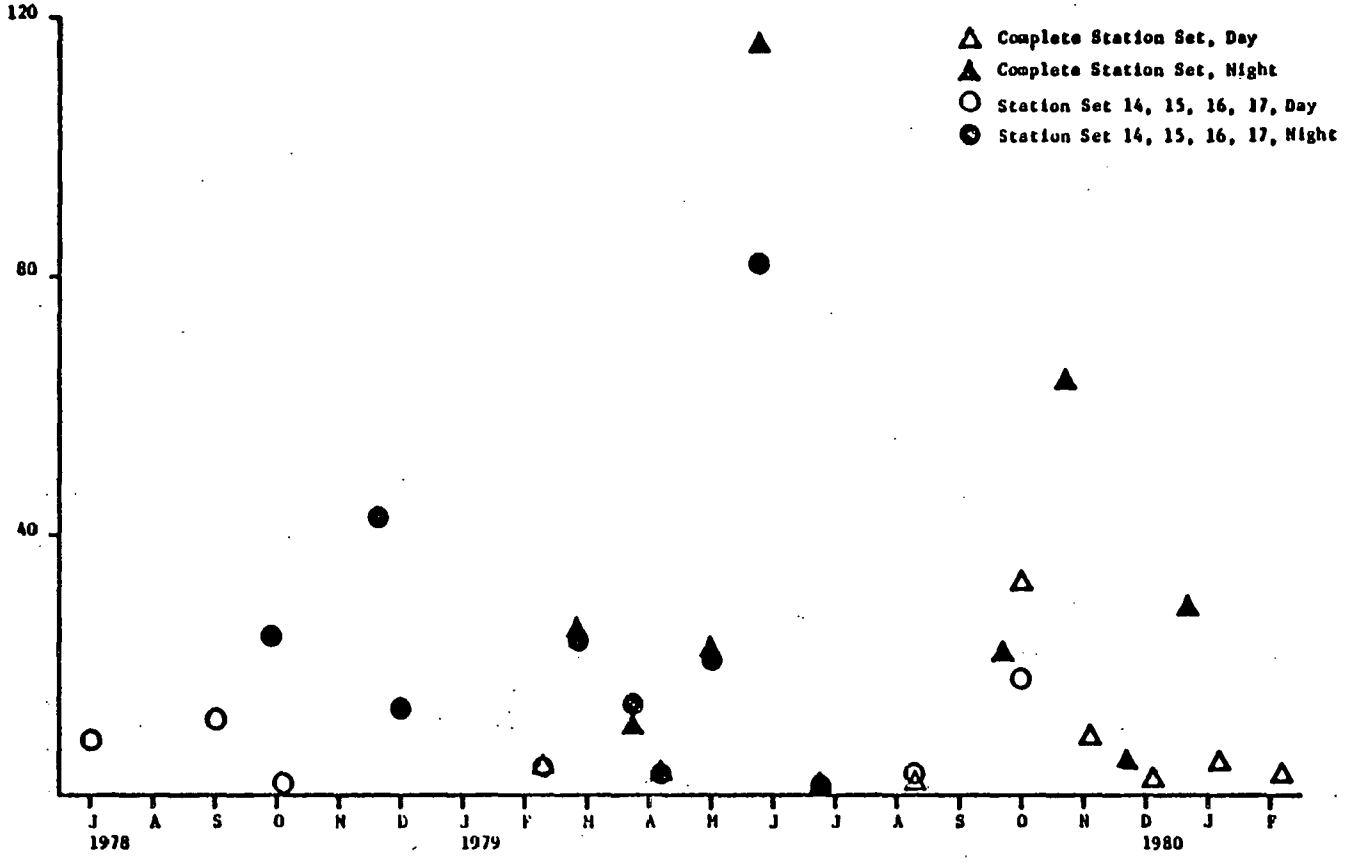

Figure 4-15. Monthly trends in geometric mean total abundance of shrimp in the diffuser area.

catches in the diffuser area. Total shrimp abundance consistently was high in the inshore area during September-December and showed a November-December peak in the diffuser area. Abundance rose during June in both areas. The seasonal patterns in abundance in the inshore and diffuser areas reflect life history patterns of the shrimp species. Increased abundance in both areas during June reflected, in part, the seasonal migrations of P. aztecus from estuarine nurseries into the Gulf. The great abundance of shrimp in the inshore area during September-December reflects increased abundance of P. aztecus and migration of P. setiferus from estuarine nurseries into the Gulf. Penaeus setiferus generally remained inshore of the diffuser area as Hann et al. (1979) noted and had less influence on Penaeid abundance there. The increased total abundance of shrimp in the diffuser area during October-November 1979 reflects the entry of many P. aztecus to that area.

4.16 Monthly and Among Stations Trends in Total Fish Abundance in the Diffuser Area

Monthly trends and among stations trends in total fish abundance are described in this section based on results of two-way analysis of variance (Tables 4-30, 4-31) and multiple range tests (Tables 4-32 - 4-36) procedures which are described in detail in Section 4.2.3. A general overview of the results of significance tests is presented in Section 4.16.1 followed by an examination of among station trends (4.16.2) and monthly trends (4.16.3). Interpretation of interaction is incorporated with the analysis of among stations differences.

4.16.1 General Overview of the Results of Significance Tests

Analysis of variance for the two night cruise X station sets and

Table 4-30. Summary of two-way analyses of variance for total abundance of fish in night cruises. See Sections 4.2.3 for list of cruises included in each analysis set.

A. Experimental design: Night cruises; diffuser stations 14, 17-25 inclusive

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	179	538.15	-	-	1.0000
Stations	9	2.84	1.80	.0783	.0053
Cruises	8	444.89	318.05	.0001	.8267
Interaction	72	74.69	5.93	.0001	.1388
Error	90	15.74	-	-	.0292

C. Experimental design: Night cruises; diffuser stations 14, 15, 16, 17

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	55	124.84	-	-	1.0000
Stations	3	0.63	0.65	.5894	.0050
Cruises	6	100.10	51.44	.0001	.8018
Interaction	18	15.03	2.57	.0121	.1204
Error	28	9.08	-	-	.0728

Table 4-31. Summary of two-way analyses of variance for total abundance of fish in day cruises. See Section 4.2.3 for list of cruises included in each analysis set.

B. Experimental design: Day cruises; diffuser stations 14, 17-25 inclusive

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	159	417.57	-	-	1.0000
Stations	9	5.91	3.68	.0007	.0142
Cruises	7	359.45	287.58	.0001	.8608
Interaction	63	37.93	3.37	.0001	.0908
Error	80	14.28	-	-	.0342

D. Experimental design: Day cruises; diffuser stations 14, 15, 16, 17

Source of Variation	df	SS	F	Pr > F	R-Square
Corrected Total	63	101.70	-	-	1.0000
Stations	3	0.97	1.35	.2748	.0088
Cruises	7	91.06	54.65	.0001	.8301
Interaction	21	10.06	2.01	.0362	.0917
Error	32	7.62	-	-	.0694

Table 4-32. Summary of Student-Newman-Keuls multiple range tests of total fish abundance between diffuser stations (14, 17-25 inclusive). Station main effects were significant at $\alpha = .0007$ in day cruises and at $\alpha = .08$ in night cruises. Means presented were antilogged after significance tests were made.

Night			Day		
Grouping	Mean	Stations	Grouping	Mean	Stations
a	146	21	a	291	17
a	141	18	a b	241	24
a	130	22	a b	239	19
a	126	14	a b	235	14
a	124	19	a b	225	25
a	116	23	a b	217	20
a	115	17	a b	193	18
a	107	25	b	174	22
a	105	24	b	161	23
a	97	20	b	154	21
21 > 20 (Marginal)			17 > 22, 23, 21		

Table 4-33. Summary of non-significant Student-Newman-Keuls multiple range tests of total fish abundance to examine interaction for station differences within cruises.

Stations 14, 17-25 inclusive		Stations 14, 15, 16, 17	
Night Cruises	Day Cruises	Night Cruises	Day Cruises
Mar, 79	Feb, 79	Oct, 78	Sep, 78
May, 79	Apr, 79	Dec, 78	Oct, 78
Jun, 79	Oct, 79	Mar, 79	Dec, 78
Oct, 79		Apr, 79	Feb, 79
Nov, 79		May, 79	Apr, 79
Jan, 80		Jun, 79	Oct, 79

Table 4-34. Summary of significant Student-Newman-Keuls multiple range tests of total fish abundance to examine interaction for station differences within cruises.

A. Experimental design: Night cruises; diffuser stations 14, 17-25 inclusive

April, 79			July, 79			December, 79		
Grouping	Mean	Station	Grouping	Mean	Station	Grouping	Mean	Station
a	5.30	21	a	4.14	18	a	5.04	23
a b	4.52	22	a	3.34	19	ab	4.79	24
b	3.53	17	b	3.12	14	abc	4.71	25
c	3.38	20	c	1.39	17	abcd	4.17	21
c	3.07	19	c	0.35	22	abcd	3.98	22
c	2.99	14	c	0.35	23	abcd	3.79	14
c	2.98	18	c	0.00	20	d	3.43	18
c	2.81	25	c	0.00	21	d	3.29	20
c	2.57	23	c	0.00	24	d	3.19	19
c	2.56	24	c	0.00	25	d	3.10	17
21, 22, 17 > rest			18 = 19, with 14 > rest			23,24,25>18,20,19,17		

C. Experimental design: Night cruises; diffuser stations 14, 15, 16, 17

July, 79		
Grouping	Mean	Station
a	4.86	15
a b	4.15	16
b	3.12	14
c	1.39	17

15, 16, 14 > 17 ; 15 > 14

D. Experimental design: Day cruises; diffuser stations 14, 15, 16, 17

July, 78			August, 79		
Grouping	Mean	Station	Grouping	Mean	Station
a	7.56	14	a	8.41	14
a b	6.34	15	a b	7.42	17
b	6.17	17	b	6.98	16
b	5.93	16	b	6.54	15
14 > 17, 16			14 > 16, 15		

Table 4-35. Summary of significant Student-Newman-Keuls multiple range tests of total fish abundance to examine interaction for station differences within cruises.

B. Experimental design: Day cruises; diffuser stations 14, 17-25 inclusive

August, 79			November, 79			December, 79		
Grouping	Mean	Station	Grouping	Mean	Station	Grouping	Mean	Station
a	8.41	14	a	5.73	25	a	3.98	17
a b	7.75	24	a	5.66	20	a b	3.41	14
a b	7.63	21	a	5.61	24	a b	3.30	24
a b	7.62	23	a	5.50	23	a b	3.30	18
a b	7.56	18	a e	5.18	14	a b	3.30	19
a b	7.42	17	a e	4.93	21	a b	3.22	25
a b	7.24	25	a e	4.84	18	a b	2.76	23
a b	7.19	20	a e	4.83	19	a b	2.72	20
a b	7.11	22	a e	4.78	17	b	2.44	21
b	6.91	19	e	4.15	22	b	2.43	22
14 > 19			25,20,24,23>22			17 > 21, 22		

January, 80			February, 80		
Grouping	Mean	Station	Grouping	Mean	Station
a	6.83	24	a	7.45	20
a	6.66	17	ab	7.08	18
a	6.61	25	bc	6.18	19
a	6.59	22	bcd	6.01	14
a e	6.10	23	bcd	6.00	24
a e	5.70	20	cd	5.71	17
a e	5.69	19	cd	5.59	21
a e	5.48	21	cd	5.54	22
e	5.19	14	cd	5.44	25
e	4.88	18	d	4.85	23
24,17,25,22 > 14,18			COMPLEX		

Table 4-36. Summary of Student-Newman-Keuls multiple range tests of total fish abundance between cruises. Means presented were anti-logged after significance tests were made.

Comparisons Based on Stations 14, 17 - 25 Inclusive

Night Cruises			Day Cruises		
Grouping	Mean	Cruise	Grouping	Mean	Cruise
a	647	Jun, 79	a	1781	Aug, 79
b	467	Oct, 79	b	521	Oct, 79
b	433	May, 79	b	397	Feb, 80
c	260	Jan, 80	b	396	Apr, 79
d	169	Mar, 79	b	392	Jan, 80
d	164	Nov, 79	e	167	Nov, 79
e	52	Dec, 79	f	22	Dec, 79
f	29	Apr, 79	f	17	Feb, 79
g	4	Jul, 79			

Comparisons Based on Stations 14, 15, 16, 17

Night Cruises			Day Cruises		
Grouping	Mean	Cruise	Grouping	Mean	Cruise
a	671	Jun, 79	a	1,538	Aug, 79
a	568	Oct, 78	ab	1,021	Oct, 78
a	482	Dec, 78	abc	975	Oct, 79
a	359	May, 79	bcd	666	Jul, 78
d	190	Mar, 79	de	412	Apr, 79
e	29	Jul, 79	ef	344	Sep, 78
e	20	Apr, 79	g	171	Dec, 78
			h	29	Feb, 79

for the two day cruise X station sets found highly significant differences among cruise main effects in each F test, but among stations main effects were significant or approached significance in only two of the four F tests. Interaction was significant in each F test, implying that a complex situation exists in which among station differences vary over cruises and are not consistent.

Among cruise variation was by far the most important source of variation in total fish abundance; variation due to interaction or among stations was comparatively unimportant. R-square values (Tables 4-30, 4-31) indicate that among cruise variation was consistent in magnitude between day and night cruises and made up 80-86% of the total variation. Interaction accounted for 12-14% of the total variation in night cruises and 9% in the day cruises. Among stations variation in total fish abundance was consistent in magnitude between day and night cruises but was negligible and accounted for only 1% of the total even in the two instances where stations main effects were significant.

4.16.2 Among Stations Trends in Total Fish Abundance in the Diffuser Area

There were relatively few instances of significant differences among diffuser stations and no consistent pattern of differences was apparent.

Observed differences among overall station means (main effects) were fairly large within cruise sets (Figure 4-16) but generally were not significant and never were consistent. Only two ANOVA instances of significant station main effects occurred and need to be considered:

1) In the night cruise set (Table 4-32), only the station of highest overall abundance (21) was significantly different than the station of lowest overall abundance (20). This pattern was not

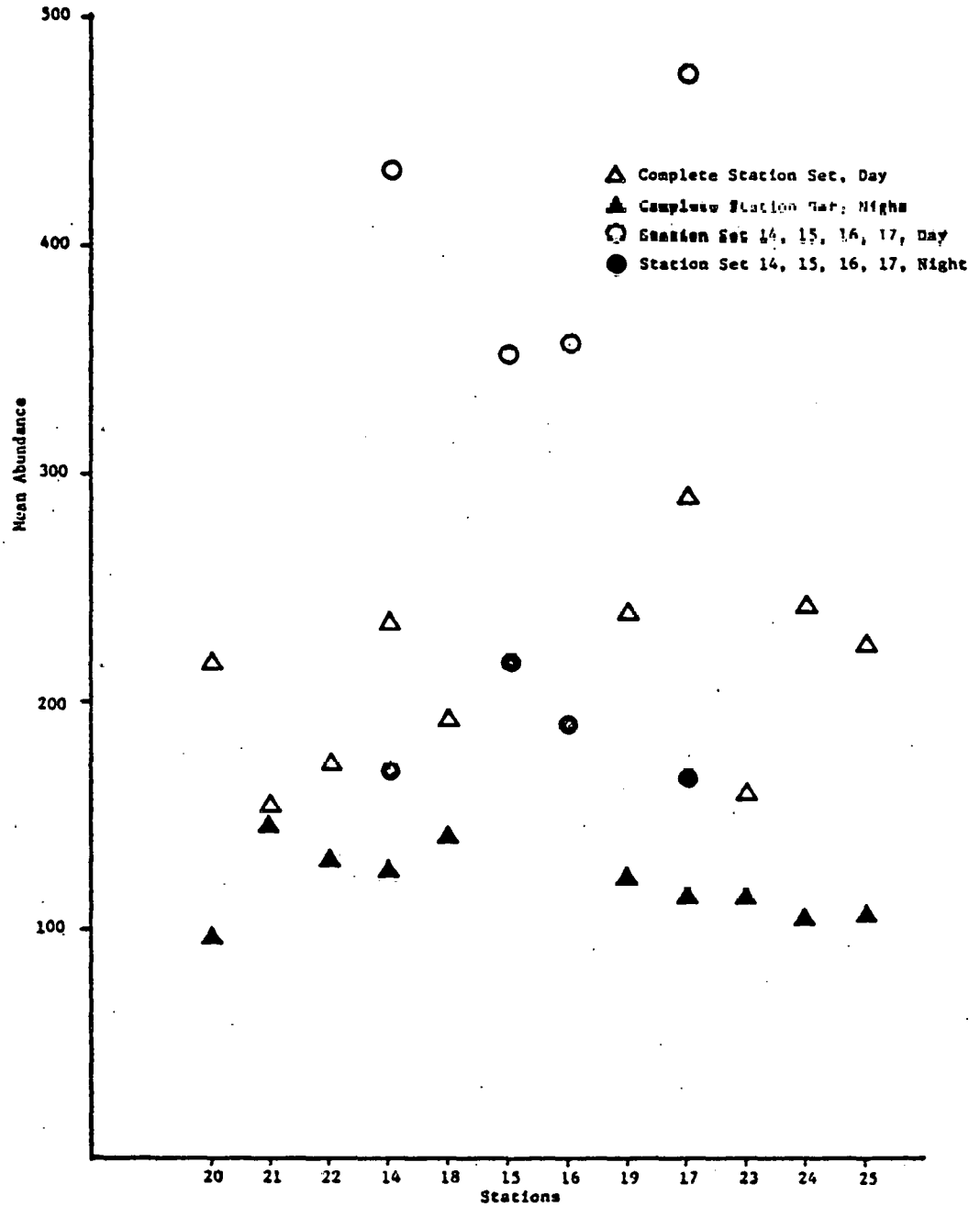

Figure 4-16. Geometric mean total abundance of fish by station in the diffuser area.

consistent, however, and it appeared in none of the nine individual night cruises when interaction was examined (Tables 4-32, 4-34). In fact, station 21 was significantly different from station 20 only on the occasion (April, 79) when the latter station showed the third highest abundance. Moreover, the pattern basically reversed in the day cruise set for which station 21 exhibited the lowest overall abundance (Table 4-32).

2) In the day cruise set (Table 4-32), only the station of highest overall abundance (17) was significantly different from the three stations of lowest overall abundance (22, 23, 21). This pattern was not consistent, however, and station 17 was significantly different from any of the latter stations in only one (December, 79) of the eight individual day cruises when interaction was examined (Tables 4-33, 4-35). Moreover, the pattern basically reversed in the night cruise set for which station 21 exhibited the highest overall abundance (Table 4-32).

Among stations differences were significant in 11 of 32 cruise X station cells examined (Tables 4-33 - 4-35), but no pattern of significant difference was consistent. Lack of consistency in differences is clearly indicated by the fact that there was no significant difference--between any stations--in two-thirds of the cells examined. Moreover, no overall station means were significantly different except for the very few differences (non-consistent ones) cited in the previous paragraph. Specific instances of significant differences described in Tables 4-34 and 4-35 also show no consistent pattern, as the following statements indicate:
1) Station 14 exhibited significantly high abundance in the August 79 day and July 79 night cruise but significantly low abundance in the

the January 80 day cruise, 2) Station 19 exhibited significantly high abundance in the July 79 night cruise but significantly low abundance in the August 79 day cruise, 3) Stations 21 and/or 22 exhibited significantly high abundance in the April 79 night and January 80 day cruises but significantly low abundance in the November 79 and December 79 day cruises, 4) Station 18 exhibited significantly high abundance in the July 79 night cruise but significantly low abundance in the December 79 night and January 80 day cruise, 5) Station 20 exhibited significantly high abundance in the November 79 day cruise but significantly low abundance in the December 79 night cruise.

Among stations differences were significant in only 3 of 15 cruise X stations cells examined which contained stations 15 and 16 (Tables 4-33, 4-34), but no pattern of significant differences was consistent. As noted above, lack of consistency in differences is clearly indicated by the fact that there was no significant differences--between any stations--in 80% of such cells examined. Moreover, no overall station means were significantly different in main effect comparisons that included stations 15 and 16 (Tables 4-30, 4-31). Specific instances of significant differences described in Tables 4-34 and 4-35 also show no consistent pattern that stations 15 and 16 differed from stations 14 and 17.

4.16.3 Monthly Trends in Total Abundance of Fishes in the Diffuser Area

Total abundance of fishes in the diffuser area in both day and night cruises showed a distinct monthly pattern, especially in 1979, and generally significant differences. Fishes generally were most abundant in the warmer months of May-October (Figure 4-17, Table 4-36). Abundance then

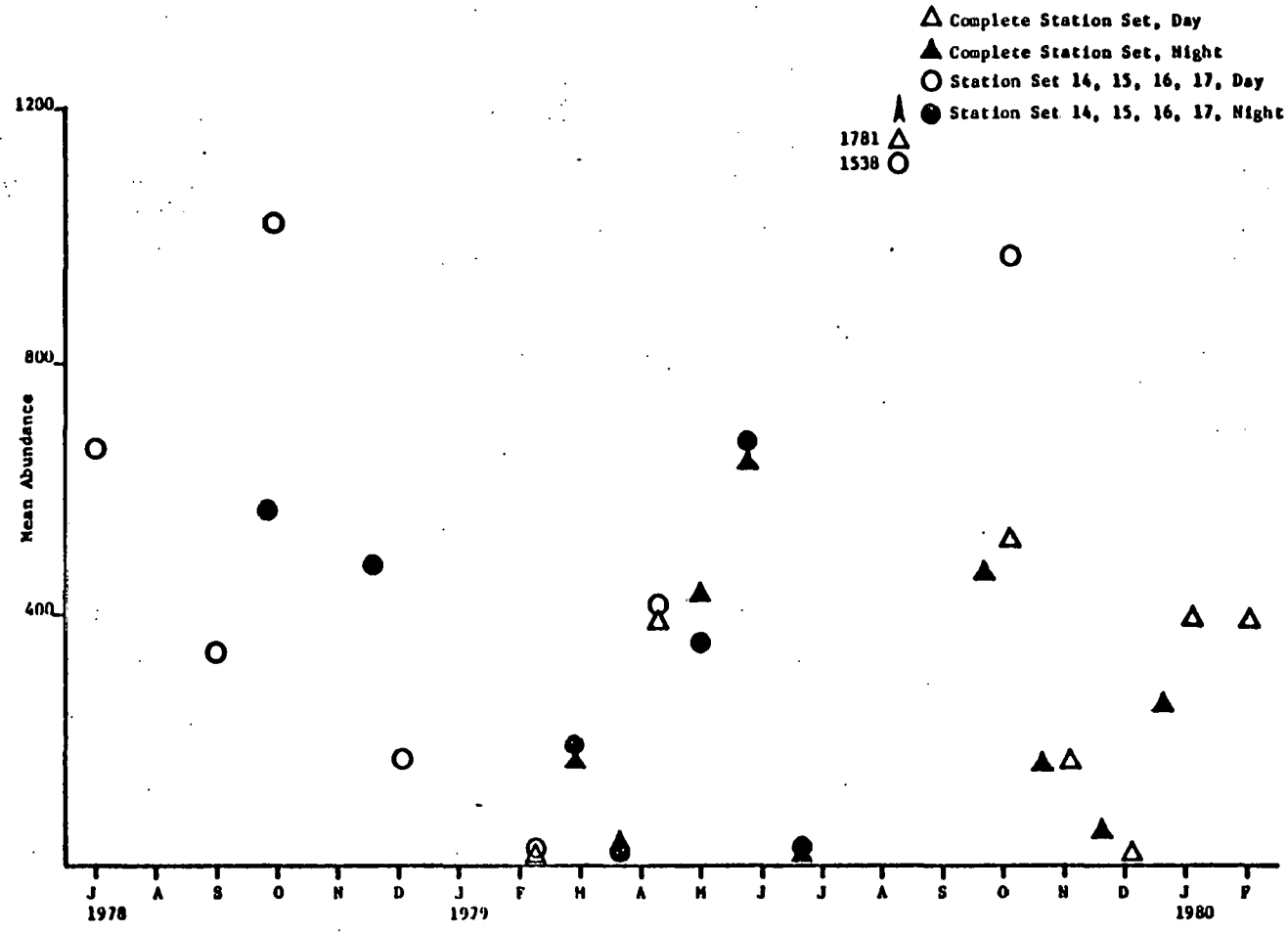

Figure 4-17. Monthly trends in geometric mean total abundance of fish in the diffuser area.

declined during the fall to lowest levels in the colder months of December-April. Catches greatly declined in the diffuser area to virtually nothing during July 1979, probably reflecting low dissolved oxygen levels at that time (see Section 4-9). Catches returned to extremely high levels in August 1979 which indicates rapid immigration of fishes into the diffuser area as oxygen conditions improved. Catches thereafter declined during the fall to reach winter lows. Trends in the fall of 1978 seemed similar to those in 1979 but were not as distinct.

4.16.4 Section Discussion

Significant differences in total fish abundance were detected among the diffuser stations, but they formed no consistent pattern and were relatively few in number, although fairly large. Among stations variation, moreover, made up only a small part of the total variation. The instances of significance found are often difficult to explain and probably largely reflect their generally well-known contagion and microspatial or microtemporal movements. All in all, it appears that fish were homogeneously distributed throughout the diffuser area in the predisposal period.

Monthly trends in total abundance of fish in the diffuser area were similar to those observed in the inshore and offshore areas. This was expected because of the generally well-known seasonal trends in abundance of fish, and discussion of monthly trends for the inshore and offshore areas (see Section 4.7.1) applies also to the diffuser area.

4.17 Comparative By Station Size Compositions of Selected Nekton in the Diffuser Area

This section briefly described comparative size compositions of

selected nekton at Stations 14-25 inclusive. Size composition data may be used to supplement the analysis of abundance-type data and indicate effects of brine disposal. The rationale for using size composition data in this manner is described in Section 4.17.1 and results are summarized in Section 4.17.2.

4.17.1 Rationale

The abundance of fisheries stocks is determined by a balance in which some processes--recruitment and immigration--increase abundance and other processes--mortality and emigration--decrease abundance. Stock abundance decreases if mortality increases in comparison to recruitment. Unless the change is marked, decreased abundance may be difficult to detect because of contagion and because immigration may be comparatively important.

Stock size or age composition also is sensitive to change in mortality rates (Ricker 1975). As mortality increases, a stock becomes juvenesced, a phenomenon in which composition changes from a stock with many older and larger individuals to one with relatively many younger, smaller individuals. Juvenescence is a classic symptom in exploited fisheries stocks because a fishery increases mortality rates, particularly a large fishery. Local stock juvenescence may also appear in areas impacted by pollution which might increase local mortality rates. Such changes would be most apparent in sedentary species not influenced greatly by immigration or emigration.

Length compositions of selected nekton at Stations 14-25 inclusive were compared within cruises to describe comparative compositions prior to brine disposal. Length composition characteristics compared between stations included size ranges and central tendencies. It was hypothesized

that effects of brine might result in size compositions that changed markedly at stations 15 and 16 to include particularly smaller individuals. And that size composition data could be additional evidence of the effects of brine disposal or lack thereof.

4.17.2 Section Results and Discussion

Length compositions of four nekton species were compared within all cruises in the period October 1977-February 1980. These species and reasons for their selection included 1) Penaeus aztecus because it is commercially important and the dominant shrimp in the diffuser area, 2) Syacium gunteri and Prionotus rubio because they often are common in the diffuser area, exhibit adaptations for a strict demersal existence and may be fairly sedentary, and 3) Cynoscion nothus because it is the most common Sciaenid species in the diffuser area year round.

There appeared to be no between stations variation in size compositions of these species within any cruise, because central tendencies and size ranges were similar at all stations. Figures 4-18 - 4-21, presented to exemplify the patterns that existed, are characteristic of all the data. Marked between stations change in size composition during the postdisposal periods, therefore, might usefully indicate an effect of brine disposal.

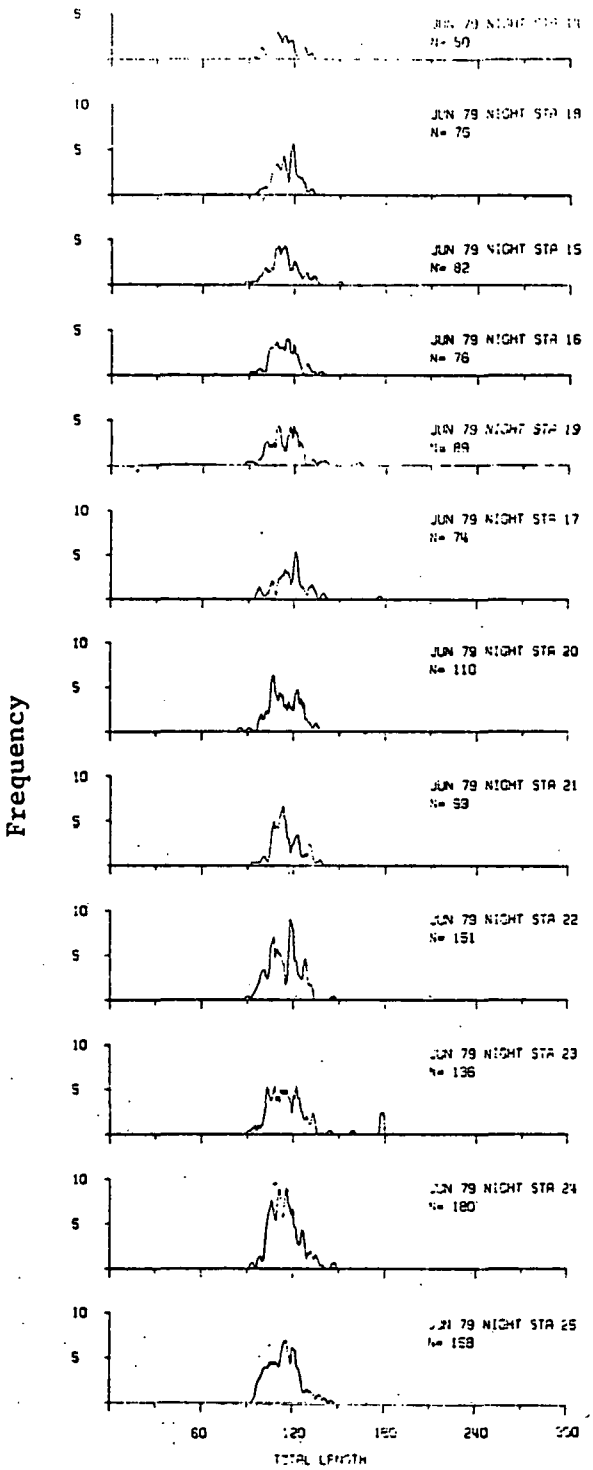

Figure 4-18. Length compositions of Penaeus aztecus by station in the Diffuser area during the June 1979 night cruise.

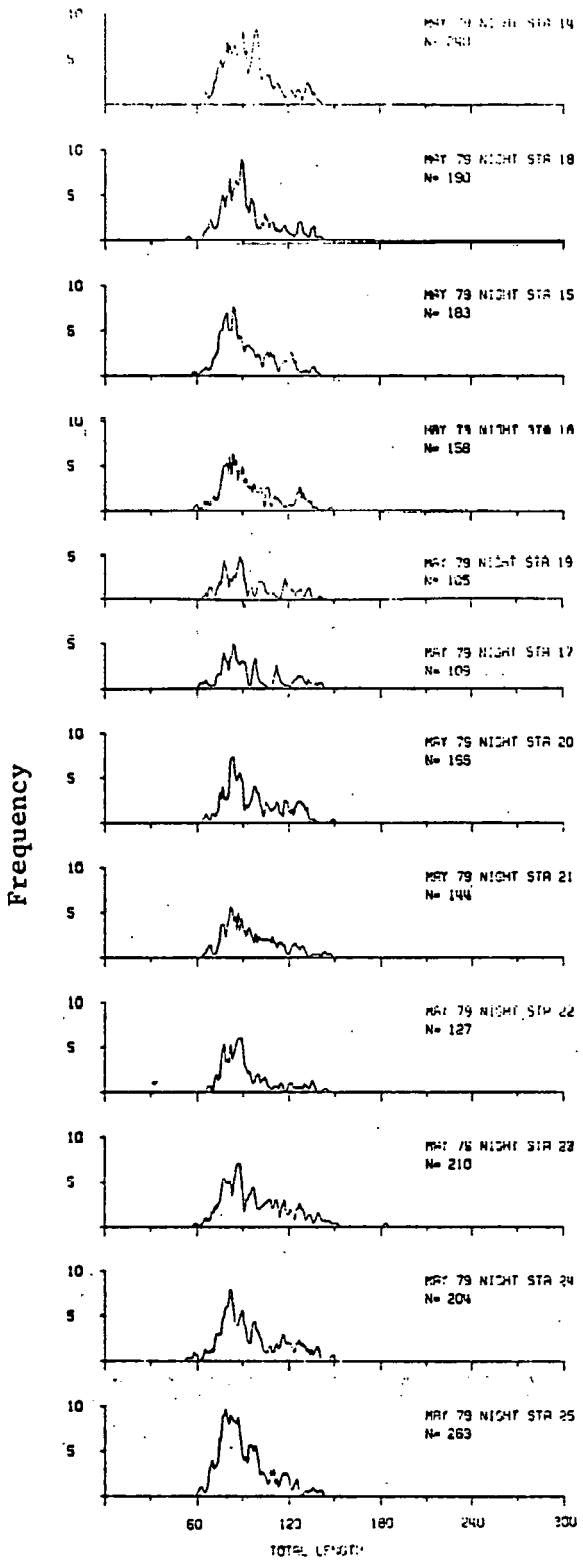

Figure 4-19. Length compositions of Syacium gunteri by station in the Diffuser area during the May 1979 night cruise.

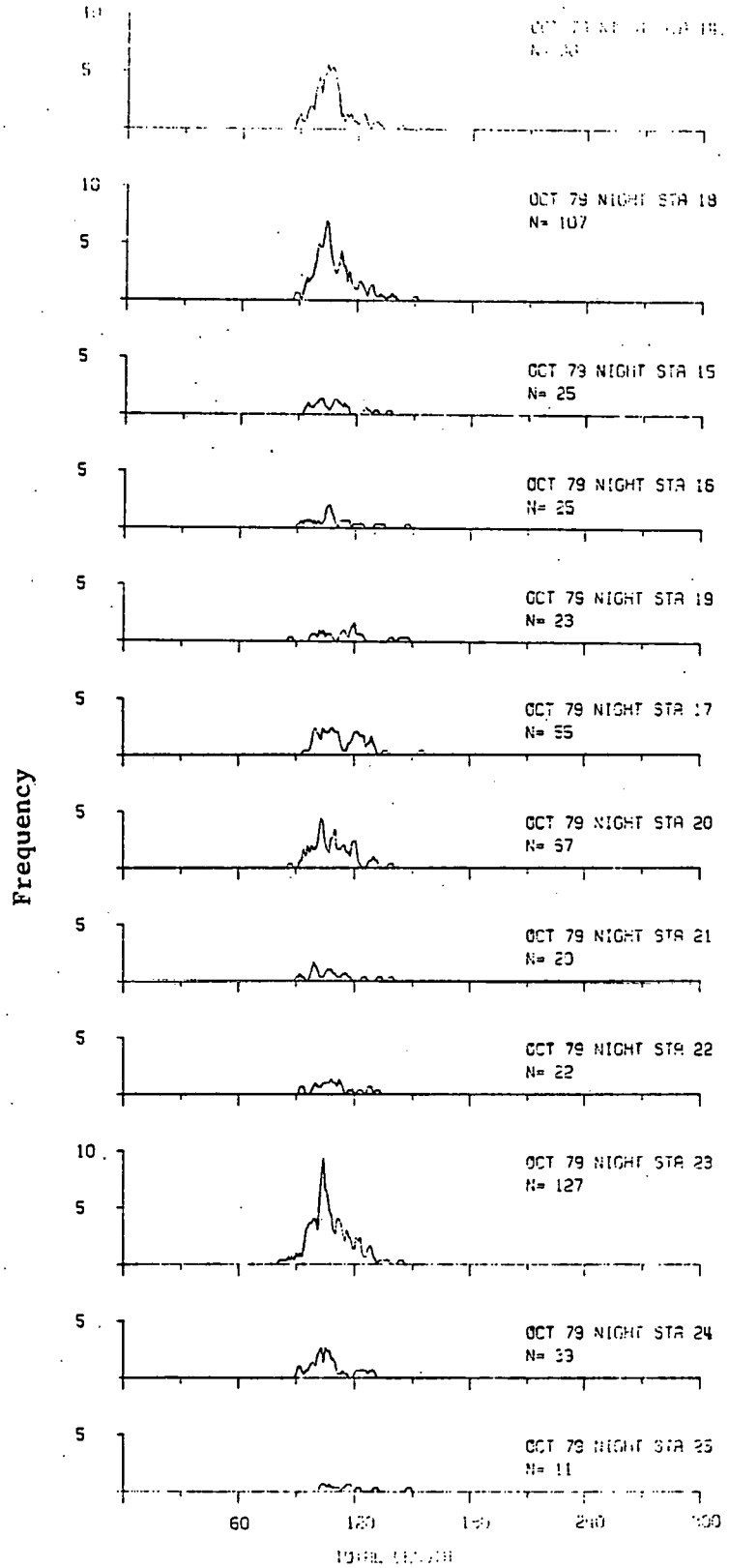

Figure 4-20. Length compositions of Prionotus rubio by station in the Diffuser area during the October 1979 night cruise.

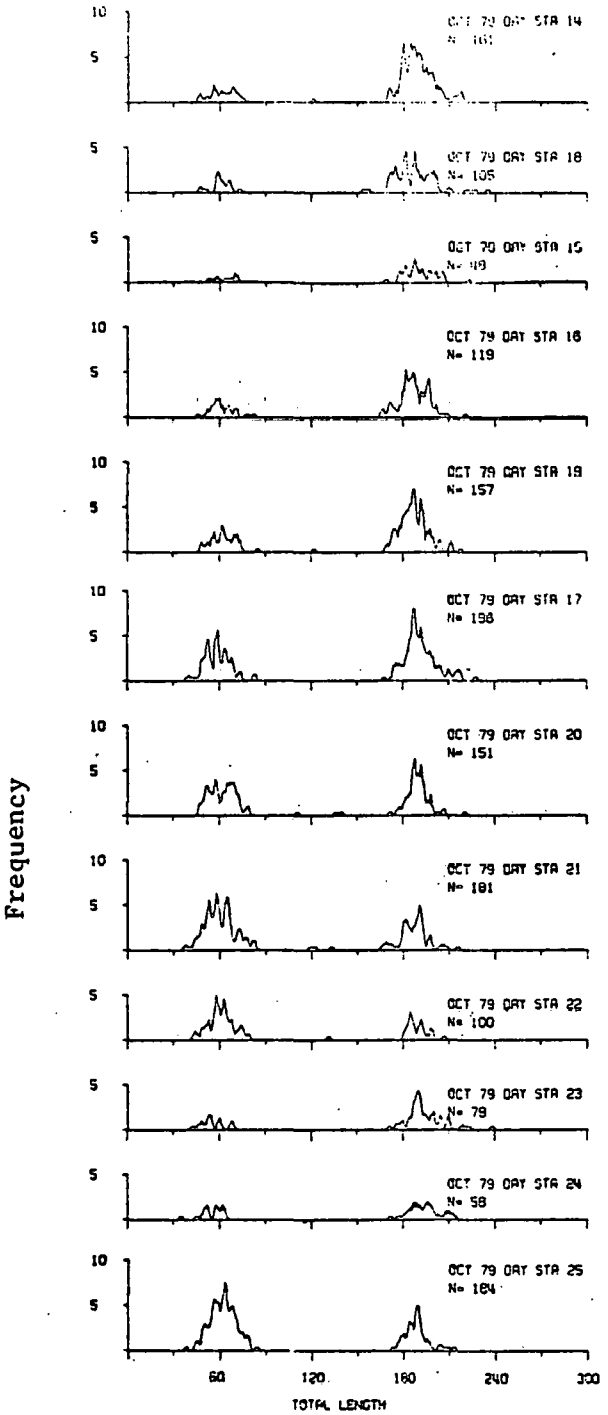

Figure 4- 21. Length compositions of Cynoscion nothus by station in the Diffuser area during the October 1979 day cruise.

4.18 Summary and General Discussion

This report describes nekton communities off Freeport, Texas prior to brine disposal based on trawl studies in the period October 1977--February 1980. Trawling was conducted aboard chartered commercial shrimp trawlers along a transect in depths of 3-25 fathoms to describe the general background of nekton communities off Freeport. An array of stations were occupied at the diffuser site in 12 fathoms of water to describe in detail nekton communities near the diffuser. Collections at each station, in general, were made once a month during the day and once a month at night, cruises being about two weeks apart in time. Projected diffuser locations, stations occupied, etc., changed during the course of the project, and the Materials and Methods (Section 4.2) should be consulted for details.

More than 37,000 Penaeid shrimp of three species and 650,000 fishes of 165 species were collected. Species compositions varied depending upon months and seasons, collection areas and depths, and time of day. Few species, however, generally dominated the catch at any one time (in any one faunal community). Penaeus aztecus and P. setiferus, in general, were the dominant shrimp off Freeport. Penaeus duorarum was relatively unimportant. Chloroscombrus chrysurus, Cynoscion nothus, and Micropogonias undulatus were the predominant fishes overall off Freeport, although Peprilus burti, Stellifer lanceolatus, Cynoscion arenarius, Syacium gunteri, Stenotomus caprinus, Trachurus lathami, and Anchoa hepsetus were also important.

Species compositions exhibited diel variation. Penaeid shrimp showed the generally recognized periodicity that catches of grooved

shrimp (Penaeus aztecus and P. duorarum) were greatest at night but catches of P. setiferus were greatest in the day. Many P. aztecus were captured during the day in the inshore waters (< 10 fathoms) in the period June-December, indicating that this species may be active during the day as it migrates offshore. Virtually no Penaeus aztecus were captured in offshore waters during the day, indicating that they undergo transition from a partly diurnal to a nocturnal pattern in the 10-15 fathom bathymetric range. Fishes also showed diel variation in catch compositions. Cynoscion nothus, Stenotomus caprinus, Prionotus rubio, and Porichthys porossissimus were more prominent in the catch at night while others, notably pelagic ones, were more important in the day including Chloroscombrus chrysurus, Peprilus burti, Trachurus lathami, and Trichiurus lepturus. These patterns generally correspond to literature cited (Section 4.4), however, direct comparisons within many 24-hour periods are needed to properly describe day-night variation for the ichthyofauna.

Species compositions showed great changes between collection areas and depths. A cluster analysis employed to delineate station groupings indicated that three major station sets existed in the sampling area off Freeport: 1) an inshore set occupying the 3-10 fathom depth range and made up of stations A, 1-8 inclusive, and 13, 2) an offshore set occupying the 20-25 fathom bathymetric range and made up of Stations 11, and 12, and 3) an intermediate set occupying the 10-15 fathom depth range and made up of stations 9, 10, 26, and 14-25 inclusive. These sets indicated by cluster analysis correspond, with minor differences, to previously selected and defined areas and station groupings used

herein to describe broad nekton communities: 1) an inshore area that included stations A, 1-9 inclusive, and 13 and occupied the 3-10 fathom depth range, 2) an offshore area that included stations 10, 11, and 12 in the 15-25 fathom depth range, and 3) the diffuser area which constituted stations 14-25 inclusive in the 12 fathom depth range. The minor differences between the previously selected station sets and clustering suggested stations sets involve the placement of stations 9, 10, and 26. The previously selected station sets were maintained for analyses herein to keep the defined diffuser area as homogeneous as possible and to separate and contrast diffuser area nekton, which is of greatest interest, from the nekton at stations further inshore and further offshore. This action was supported by: 1)within cluster set patterns suggesting that stations 9 and 10 were somewhat dissimilar to the stations 14-25 inclusive in the previously defined diffuser area, 2) analysis of among stations data which indicated that percentage compositions of Penaeus aztecus, P. setiferus, Cynoscion nothus, and Syacium gunteri at stations 9, 10, and 26 were at or outside the extreme values of percentage composition ranges for stations in the defined diffuser area, and 3) patterns of species abundance (Hann et al. 1979) that indicate changing abundance of many prominent species between station 9 and the defined diffuser area.

The defined inshore area was characterized by nekton of the white shrimp community. The fauna was dominated by Penaeus setiferus and by fishes of the family Sciaenidae, especially Micropogonias undulatus, Cynoscion nothus, Stellifer lanceolatus, and Cynoscion arenarius. The pelagic Chloroscombrus chrysurus was very abundant and other important species included Peprilus burti, Anchoa mitchilli, and Ariopsis felis. With few exceptions, notably the pelagic fishes, the inshore fauna was

similar to the fauna of the white shrimp community described by Chittenden and McEachran (1976).

The defined offshore area was characterized by nekton of the brown shrimp community. The fauna was dominated by P. aztecus and by Stenotomus caprinus of the family Sparidae. A rich variety of other species were important including Syacium gunteri, Upeneus parvus, Diplectrum bivittatum, Centropristis philadelphica, Synodus foetens, and Saurida brasiliensis. Widely distributed pelagic fishes such as Chloroscombrus chrysurus, Trachurus lathami, and Peprilus burti also were abundant. With few exceptions, notably the pelagic forms again, the fauna of the brown shrimp community was similar to that described by Chittenden and McEachran (1976) and Chittenden and Moore (1977).

The defined diffuser area was characterized by a mixture of nekton of the white and brown shrimp communities. The fauna was dominated by Penaeus aztecus and the fishes Chloroscombrus chrysurus and Cynoscion nothus. Other important taxa included Penaeus setiferus, Peprilus burti, Syacium gunteri, Cynoscion arenarius, Stenotomus caprinus, Anchoa hepsetus, Prionotus rubio, and Trachurus lathami.

The nekton in the diffuser area clearly reflect ecological transition between faunas of the inshore white and offshore brown shrimp communities, a pattern also supported by cluster analysis to delineate station groupings, by the changing abundance of important species at 10-12 fathoms, and by between stations change in percentage compositions of important fauna in the 10-15 fathom depth range noted later. Both P. aztecus and P. setiferus (winter only) were common in the diffuser area although previous analyses of white shrimp life history (Hann et al. 1979) indicated that the diffuser area was near the bathymetric limit for P. setiferus. The

ichthyofauna of the diffuser area reflects typical members of the white shrimp community (such as Cynoscion nothus and C. arenarius) and from the brown shrimp community (such as Syacium gunteri and Stenotomus caprinus). The ichthyofauna near the diffuser also was characterized by an abundance of pelagic forms that are widespread in the white and brown shrimp communities such as Chloroscombrus chrysurus, Trachurus lathami, Peprilus burti. Patterns of changing abundance of many important species (Hann et al. 1979) also indicate that the diffuser area is in an ecological transition zone. Although seasonal movements occur, many species show decreased abundance in 10-15 fathoms offshore of Station 9 or the diffuser area including Penaeus setiferus, Micropogonias undulatus, Cynoscion nothus, Cynoscion arenarius, Menticirrhus americanus, Stellifer lanceolatus, Ariopsis felis, Polydactylus octonemus and Trichiurus lepturus. These patterns of changing abundance in 10-15 fathom depths were also reflected in changing percentage compositions, another indication of ecological transition. The typical inshore forms Penaeus setiferus and Cynoscion nothus showed generally decreasing percentage composition from station 9 into deeper water at station 10, but the more offshore forms Penaeus aztecus and Syacium gunteri showed an opposite pattern.

The Penaeid shrimp community and the fish community each showed decreasing abundance with increased depth and distance from shore. Abundance of fish and shrimp generally was greatest by far at stations (A and 1) that were in 3-5 fathom depths and furthest inshore. Fish abundance sharply declined further from shore in waters of five fathoms and thereafter continued to decline, although between stations differences were not large.

The Penaeid shrimp community and the fish community each showed

important monthly trends in abundance. Monthly trends in the total abundance of fish were similar in the inshore, offshore, and diffuser areas. Fish generally were most abundant in the warmer months of May-October and then declined in abundance during fall to minimum levels in the colder months of December-April. Penaeid shrimp also showed monthly trends that were similar in the inshore and diffuser areas. Abundance was high in the fall about September-December when Penaeus setiferus enters the Gulf from estuarine nurseries and when Penaeus aztecus again became abundant. Abundance declined after December, remained low through May, and rose in June when P. aztecus enters the Gulf from estuarine nurseries. Penaeid shrimp collections in the offshore area at night generally followed trends in abundance in the inshore and diffuser areas. Few shrimp were captured in the offshore area during the day because P. aztecus the dominant species is nocturnal in the offshore waters.

The observed annual cycle in abundance of fish and Penaeid shrimp is similar to cycles described by Chittenden and McEachran (1976) and Van Lopik et al. (1979). A general trend has been reported by many authors that there is a great reduction in the fish fauna during the winter in warm temperate waters, a condition specifically described for Texas by Gunter (1945, 1958) and McFarland (1963).

Great, unexpected reductions in abundance of fish and shrimp were observed on several occasions in June and July associated with low dissolved oxygen levels in bottom waters. Demersal nekton was virtually eliminated during July 1979 over a broad geographical area extending from station 2 in seven fathoms of water through station 26 in 13 fathoms, a range which encompassed the entire defined diffuser area. Catches of fish returned to extremely high levels in the diffuser area

during August, reflecting their rapid immigration, but catches of shrimp remained low in that area until October-November.

Compositions of the Penaeid shrimp fauna and ichthyofauna showed seasonal patterns superimposed on community changes with depth. Penaeus setiferus dominated the catch in the inshore area during summer, fall, and winter, was important in the catch at the diffuser area during winter, and was virtually absent from the offshore area year round. Penaeus aztecus dominated the catch in the offshore area year round. This species dominated the catch in the inshore area during spring and was predominant in the diffuser area during spring, summer, fall, and even in winter when P. setiferus became important. Compositions of the ichthyofauna showed marked seasonal change associated with their generally undescribed life history patterns, especially their recruitment and movements. Seasonal inshore-offshore recruitment or movements formed two important patterns: 1) many demersal fishes such as Ariopsis felis, Polydactylus octonemus, and Stellifer lanceolatus, and widespread pelagic fishes such as Chloroscombrus chrysurus and Trachurus lathami moved offshore for the colder months and moved inshore or recruited there during the warmer months, 2) many demersal fishes such as Syacium gunteri, Synodus foetens, Saurida brasiliensis, and Urophycis floridanus moved inshore or recruited there during the colder months and moved offshore during the warmer months. The transitional nature of the nekton community in the diffuser area, in part, results from inshore-offshore movements of its fauna. Sections 4.8 and 4.14 should be consulted for more detail about seasonal trends in the nekton, and Appendix Tables 7-8 - 7-20 document monthly trends in each area.

Two important estuarine sport fishes, the red drum and black drum,

were captured regularly in depths of 8-12 fathoms during winter as Chittenden and McEachran (1976) observed for the same area in 1973-74. Large numbers of these fishes were never captured, but they are large fish and active enough that they could readily avoid nets towed for short periods.

Among stations percentage compositions of the important nekton were very similar at Stations 14-25 inclusive in the defined diffuser area and agree with the results of cluster analysis that stations in the defined diffuser area formed a basically homogeneous set. Percentage compositions of Penaeus aztecus, P. setiferus, Cynoscion nothus, and Syacium gunteri at stations 9, 10, and 26 differed from those at stations 14-25 inclusive in a pattern that reflected the transitional nature of the 10-15 fathom bathymetric range.

Among stations size compositions of Penaeus aztecus, Cynoscion nothus, Prionotus rubio, and Syacium gunteri in the defined diffuser area were compared within all cruises during the predisposal period. No among stations size differences were apparent, so that among stations change after brine disposal might indicate an increased mortality associated with brine discharge.

Analysis of variance and multiple comparisons procedures were used to evaluate monthly trends and among stations trends in total shrimp abundance and total fish abundance in the defined diffuser area. Variation among cruises (monthly trends) was by far the most important component of the total variation in total shrimp and total fish abundance as measured by values of R-square. Among stations variation was negligible in the few instances when this main effect was significant. Interaction was significant in 3 of 4 F tests made for shrimp and in 2 of 4 F tests made

for fish. Detailed analyses of among stations main effects and interaction found few significant differences in total abundance of shrimp or total abundance of fish, and no consistent pattern of differences was apparent. The few instances of significance found probably reflect contagion and microspatial or microtemporal movements.

All in all, it appears that Penaeid shrimp and fish basically were homogeneously distributed throughout the defined diffuser area in the predisposal period as indicated by cluster analysis and by among stations comparisons of percentage compositions, total abundance, and size compositions.

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Appendix Table 7-1. Summary of the species and families of fishes identified off Freeport, Texas, October 1977-February 1980.

Carcharhinidae

- Carcharhinus acronotus
- Carcharhinus brevipinna
- Carcharhinus plumbeus
- Carcharhinus porosus
- Rhizoprionodon terraenovae

Triakidae

- Mustelus canis

Sphyrnidae

- Sphyrna lewini
- Sphyrna tiburo

Gobiesocidae

- Gobiesox strumosus

Rajidae

- Raja texana

Dasyatidae

- Dasyatis americanus
- Dasyatis sabina
- Dasyatis sayi

Rhinopteridae

- Rhinoptera bonasus

Elopidae

- Elops saurus

Muraenidae

- Gymnothorax nigromarginatus

Muraenisocidae

- Hoplunnis macrurus
- Hoplunnis tenuis

Congridae

APPENDIX 7

Supporting Data for Nekton Studies

Hildebrandia flava

Ophichthidae

Echiopsis punctifer
Ophichthus gomesi

Clupeidae

Alosa chrysochloris
Brevoortia patronus
Dorosoma petenense
Etrumeus teres
Harengula jaguana
Opisthonema oglinum
Sardinella aurita

Engraulidae

Anchoa hepsetus
Anchoa lyolepis
Anchoa mitchilli
Engraulis eurystole

Synodontidae

Saurida brasiliensis
Synodus foetens
Synodus poeyi
Trachinocephalus myops

Ariidae

Ariopsis felis
Bagre marinus

Batrachoididae

Porichthys porosissimus

Antennariidae

Antennarius radiosus
Phrynelox scaber

Ogcocephalidae

Halieutichthys aculeatus
Ogcocephalus sp.

Bregmacerotidae

Bregmaceros atlanticus

Gadidae

Urophycis cirratus
Urophycis floridanus

Ophidiidae

Lepophidium graellsi
Ophidion grayi
Ophidion holbrooki
Ophidion welshi

Brotulidae

Brotula barbata

Exocoetidae

Parexcoetus brachypterus

Hemiramphidae

Hemirhamphus brasiliensis

Atherinidae

Membras martinica
Menidia beryllina

Syngnathidae

Hippocampus erectus
Syngnathus louisianae

Serranidae

Centropristis philadelphica
Diplectrum bivittatum
Epinephelus niveatus
Serraniculus pumulio
Serranus atrobranchus
Serranus subligarius

Grammistidae

Rypticus maculatus

Priacanthidae

Priacanthus arenatus

Branchiostegidae

Caulolatilus intermedius

Pomatomidae

Pomatomus saltator

Echeneidae

Echeneis naucrates

Rachycentridae

Rachycentron canadum

Carangidae

Caranx crysos
Caranx hippos
Chloroscombrus chrysurus
Decapterus punctatus
Hemicaranx amblyrhynchus
Oligoplites saurus
Selar crumenophthalmus
Selene setapinnis
Selene vomer
Trachinotus carolinus
Trachurus lathami

Lutjanidae

Lutjanus campechanus
Pristipomoides aquilonaris
Rhomboplites aurorubens

Gerreidae

Eucinostomus argenteus
Eucinostomus gula
Eucinostomus melanopterus

Pomadasyidae

Conodon nobilis
Haemulon aurolineatum
Orthopristis chrysoptera

Sparidae

Archosargus probatocephalus
Lagodon rhomboides
Stenotomus caprinus

Sciaenidae

Bairdiella chrysoura
Cynoscion arenarius
Cynoscion nebulosus
Cynoscion nothus
Larimus fasciatus
Leiostomus xanthurus
Menticirrhus americanus
Menticirrhus littoralis
Micropogonias undulatus
Pareques umbrosus
Pogonias cromis
Sciaenops ocellata
Stellifer lanceolatus

Mullidae

Mullus auratus
Upeneus parvus

Ephippidae

Chaetodipterus faber

Mugilidae

Mugil cephalus

Sphyraenidae

Sphyraena guachancho

Polynemidae

Polydactylus octonemus

Opistognathidae

Lonchopisthus lindneri
Opistognathus sp.

Uranoscopidae

Astroscopus y-graecum

Gobeidae

Bollmannia communis
Gobionellus hastatus

Trichiuridae

Trichiurus lepturus

Scombridae

Scomberomorus cavalla
Scomberomorus maculatus
Scomber japonicus

Stromateidae

Peprilus burti
Peprilus paru

Scorpaenidae

Scorpaena calcarata

Triglidae

Bellator militaris
Prionotus ophryas
Prionotus paralatus
Prionotus roseus
Prionotus rubio
Prionotus salmonicolor
Prionotus scitulus
Prionotus stearnsi
Prionotus tribulus

Dactylopteridae

Dactylopterus volitans

Bothidae

Ancylopsetta dilecta
Ancylopsetta quadrocellata
Citharichthys macrops
Citharichthys spilopterus
Cyclopsetta chittendeni
Engyophrys senta
Etropus crossotus
Paralichthys albigutta
Paralichthys lethostigma
Paralichthys squamilentus
Syacium gunteri
Syacium papillosum
Trichopsetta ventralis

Soleidae

Achirus lineatus
Gymnachirus texae
Trinectes maculatus

Cynoglossidae

Symphurus civitatus
Symphurus diomedianus
Symphurus plagiusa
Symphurus urospilus

Balistidae

Balistes capriscus

Monacanthidae

Aluterus schoepfi
Cantherhines pullus
Stephanolepis hispidus
Stephanolepis setifer

Ostraciidae

Acanthostracion quadricornis

Tetraodontidae

Chilomycterus schoepfi
Lagocephalus laevigatus
Sphoeroides dorsalis
Sphoeroides parvus
Sphoeroides spengleri

Penaeidae

Penaeus aztecus
Penaeus duorarum
Penaeus setiferus

Appendix Table 7-2. Composition of Dominant and Non-dominant Species of Fish. Station 9. October, 1977 - February, 1980.

Dominant Species (11)	Number	%	Cum. %
CYNOSCION NOTHUS	4690	25.54	25.54
CHLOROSCOMBRUS CHRYSURUS	4096	22.30	47.84
PEPRILUS BURTI	1108	6.03	53.87
TRACHURUS LATHAMI	1086	5.91	59.79
CYNOSCION ARENARIUS	1022	5.56	65.35
SYACIUM GUNTERI	706	3.84	69.20
ANCHOA MITCHILLI	694	3.78	72.98
ARIOPSIS FELIS	558	3.04	76.01
STENOTOMUS CAPRINUS	480	2.61	78.63
PRIONOTUS RUBIO	400	2.18	80.81
ANCHOA LYOLEPIS	371	2.02	82.83
Non-Dominant Species (76)			
MICROPOGONIAS UNDULATUS	304	1.66	84.48
ANCHOA HEPSETUS	230	1.25	85.73
HARENGULA JAGUANA	226	1.23	86.96
CENTROPRISTIS PHILADELPHIC	205	1.12	88.08
TRICHIURUS LEPTURUS	199	1.08	89.16
SPHOEROIDES PARVUS	187	1.02	90.18
DIPLECTRUM BIVITTATUM	183	1.00	91.18
ETROPUS CROSSOTUS	174	0.95	92.13
LEPOPHIDIUM GRAELLSI	138	0.75	92.88
PORICHTHYS POROSISSIMUS	134	0.73	93.61
SERRANICULUS PUMULIO	82	0.45	94.05
POLYDACTYLUS OCTONEMUS	78	0.42	94.48
HALIEUTICHTHYS ACULEATUS	74	0.40	94.88
LUTJANUS CAMPECHANUS	73	0.40	95.28
LEIOSTOMUS XANTHURUS	71	0.39	95.67
UPENEUS PARVUS	59	0.32	95.99
ORTHOPRISTIS CHRYSOPTERA	59	0.32	96.31
OPISTHONEMA OGLINUM	58	0.32	96.62
PRIONOTUS SALMONICOLOR	53	0.29	96.91
MENTICIRRHUS AMERICANUS	50	0.27	97.18
PEPRILUS PARU	48	0.26	97.45
SYNODUS FOETENS	46	0.25	97.70
SAURIDA BRASILIENSIS	43	0.23	97.93
UROPHYCIS FLORIDANUS	41	0.22	98.15
SELENE SETAPINNIS	39	0.21	98.37
PRIONOTUS TRIBULUS	34	0.19	98.55
LARIMUS FASCIATUS	31	0.17	98.72
SYMPHURUS CIVITATUS	22	0.12	98.84
OGCOCEPHALUS SP.	22	0.12	98.96
CITHARICHTHYS SPILOPTERUS	18	0.10	99.06
SCORPAENA CALCARATA	16	0.09	99.14
LAGODON RHOMBOIDES	13	0.07	99.22
LUTJANUS SYNAGRIS	12	0.07	99.28
ANCYLOPSETTA QUADROCELLATA	11	0.06	99.34
BALISTES CAPRISCUS	10	0.05	99.40
CHAETODIPTERUS FABER	8	0.04	99.44
PRIONOTUS SCITULUS	7	0.04	99.48
OPHIDION WELSHI	7	0.04	99.51
BREVOORTIA PATRONUS	7	0.04	99.55
SARDINELLA AURITA	6	0.03	99.59
GYMNACHIRUS TEXAE	5	0.03	99.61
SPHYRAENA GUACHANCHO	5	0.03	99.64

Appendix Table 7-2. (Continued).

SCOMBEROMORUS CAVALLA	5	0.03	99.67
ENGRAULIS EURYSTOLE	4	0.02	99.69
SYMPHURUS PLAGIUSA	4	0.02	99.71
PRIONOTUS OPHRYAS	4	0.02	99.73
BAGRE MARINUS	3	0.02	99.75
STELLIFER LANCEOLATUS	3	0.02	99.77
ARCHOSARGUS PROBATOCEPHALU	3	0.02	99.78
SPHYRNA TIBURO	3	0.02	99.80
EUCINOSTOMUS ARGENTEUS	3	0.02	99.81
OPHIDION HOLBROOKI	2	0.01	99.83
ECHIOPSIS PUNCTIFER	2	0.01	99.84
BROTULA BARBATA	2	0.01	99.85
SCOMBEROMORUS MACULATUS	2	0.01	99.86
CARANX HIPPOS	2	0.01	99.87
LAGOCEPHALUS LAEVIGATUS	2	0.01	99.88
HEMICARANX AMBLYRHYNCHUS	2	0.01	99.89
PARALICHTHYS LETHOSTIGMA	2	0.01	99.90
POGONIAS CROMIS	2	0.01	99.91
ELOPS SAURUS	1	0.01	99.92
SYACIUM PAPILLOSUM	1	0.01	99.92
ETRUMEUS TERES	1	0.01	99.93
PARALICHTHYS ALBIGUTTA	1	0.01	99.93
EUCINOSTOMUS GULA	1	0.01	99.94
EUCINOSTOMUS MELANOPTERUS	1	0.01	99.94
STEPHANOLEPIS HISPIDUS	1	0.01	99.95
CYCLOPSETTA CHITTENDENI	1	0.01	99.96
ASTROSCOPUS Y-GRAECUM	1	0.01	99.96
DASYATIS AMERICANUS	1	0.01	99.97
SYNGNATHUS LOUISIANAE	1	0.01	99.97
PRIACANTHUS ARENATUS	1	0.01	99.98
PRIONOTUS PARALATUS	1	0.01	99.98
SYNODUS POEYI	1	0.01	99.99
PRISTIPOMOIDES AQUILONARIS	1	0.01	99.99
MUGIL CEPHALUS	1	0.01	100.00
TOTAL	18365		

Appendix Table 7-3. Composition of dominant and non-dominant species of fish. Station 10, October 1977 - February 1980.

Dominant Species (9)	Total Catch	Mean Catch	%	Cum %
Chloroscombrus chrysurus	4905	90.83	22.34	22.34
Syacium gunteri	4580	84.81	20.86	43.19
Diplectrum bivittatum	2734	50.63	12.45	55.64
Trachurus lathami	1522	28.19	6.93	62.58
Stenotomus caprinus	1166	21.59	5.31	67.89
Prionotus rubio	956	17.70	4.35	72.24
Peprilus burti	648	12.00	2.95	75.19
Cynoscion arenarius	616	11.41	2.81	78.00
Saurida brasiliensis	555	10.28	2.53	80.52
Non-Dominant Species (74)				
Centropristis philadelphica	377	6.98	1.72	82.24
Synodus foetens	366	6.78	1.67	83.91
Anchoa hepsetus	356	6.59	1.62	85.53
Etropus crossotus	292	5.41	1.33	86.86
Priacanthus arenatus	290	5.37	1.32	88.18
Upeneus parvus	257	4.76	1.17	89.35
Lutjanus campechanus	252	4.67	1.15	90.50
Porichthys porosissimus	250	4.63	1.14	91.63
Lepophidium graellsi	203	3.76	0.92	92.56
Halieutichthys aculeatus	181	3.35	0.82	93.38
Engyophrys senta	142	2.63	0.65	94.03
Cynoscion nothus	129	2.39	0.59	94.62
Ogcocephalus declivirostris	111	2.06	0.51	95.12
Anchoa mitchilli	111	2.06	0.51	95.63
Bollmannia communis	100	1.85	0.46	96.08
Sphoeroides parvus	95	1.76	0.43	96.52
Cyclopsetta chittendeni	91	1.69	0.41	96.93
Etrumeus teres	70	1.30	0.32	97.25
Micropogonias undulatus	64	1.19	0.29	97.54
Trichiurus lepturus	57	1.06	0.26	97.80
Symphurus civitatus	47	0.87	0.21	98.01
Gymnachirus texae	43	0.80	0.20	98.21
Citharichthys spilopterus	41	0.76	0.19	98.40
Lagocephalus laevigatus	39	0.72	0.18	98.57
Anchoa lyolepis	30	0.56	0.14	98.71
Synodus poeyi	27	0.50	0.12	98.83
Bregmaceros atlanticus	24	0.44	0.11	98.94
Harengula jaguana	19	0.35	0.09	99.03
Urophycis floridanus	17	0.31	0.08	99.11
Prionotus paralatus	17	0.31	0.08	99.18
Scorpaena calcarata	17	0.31	0.08	99.26
Lagodon rhomboides	16	0.30	0.07	99.33
Selene setapinnis	15	0.28	0.07	99.40
Prionotus salmonicolor	14	0.26	0.06	99.47

Appendix Table 7-3 (Continued).

	Total Catch	Mean Catch	%	Cum %
Ancylopsetta quadrocellata	11	0.20	0.05	99.52
Lutjanus synagris	10	0.19	0.05	99.56
Peprilus paru	7	0.13	0.03	99.59
Chaetodipterus faber	6	0.11	0.03	99.62
Opisthonema oglinum	6	0.11	0.03	99.65
Prionotus tribulus	5	0.09	0.02	99.67
Pristipomoides aquilonaris	5	0.09	0.02	99.69
Orthopristis chrysoptera	4	0.07	0.02	99.71
Menticirrhus americanus	4	0.07	0.02	99.73
Leiostomus xanthurus	4	0.07	0.02	99.75
Sphyrna tiburo	4	0.07	0.02	99.77
Paralichthys albigutta	4	0.07	0.02	99.79
Paralichthys lethostigma	4	0.07	0.02	99.80
Urophycis cirratus	3	0.06	0.01	99.82
Raja texana	3	0.06	0.01	99.83
Eucinostomus gula	3	0.06	0.01	99.84
Prionotus ophryas	3	0.06	0.01	99.86
Brevoortia patronus	3	0.06	0.01	99.87
Brotula barbata	2	0.04	0.01	99.88
Scomber japonicus	2	0.04	0.01	99.89
Rhizoprionodon terraenovae	2	0.04	0.01	99.90
Sphyraena guachancho	2	0.04	0.01	99.91
Prionotus stearnsi	2	0.04	0.01	99.92
Balistes capriscus	2	0.04	0.01	99.93
Pareques umbrosus	1	0.02	0.00	99.93
Eucinostomus argenteus	1	0.02	0.00	99.94
Hippocampus erectus	1	0.02	0.00	99.94
Caranx crysos	1	0.02	0.00	99.94
Gymnothorax nigromarginatus	1	0.02	0.00	99.95
Larimus fasciatus	1	0.02	0.00	99.95
Syacium papillosum	1	0.02	0.00	99.96
Bellator militaris	1	0.02	0.00	99.96
Mustelus canis	1	0.02	0.00	99.97
Selene vomer	1	0.02	0.00	99.97
Serraniculus pumulio	1	0.02	0.00	99.98
Serranus subligarius	1	0.02	0.00	99.98
Stephanolepis hispidus	1	0.02	0.00	99.99
Archosargus probatocephalus	1	0.02	0.00	99.99
Serranus atrobranchus	1	0.02	0.00	99.99
Pogonias cromis	1	0.02	0.00	100.00
Number of Tows	54			
TOTAL	21959			

Appendix Table 7-4. Composition of dominant and non-dominant species of fish. Station 26. October 1977-February 1980.

Dominant Species (11)	Number	%	Cum. %
Chloroscombrus chrysurus	2185	16.52	16.52
Syacium gunteri	2032	15.37	31.89
Peprilus burti	1738	13.14	45.03
Cynoscion arenarius	1282	9.69	54.72
Diplectrum bivittatum	930	7.03	61.75
Cynoscion nothus	745	5.63	67.38
Prionotus rubio	497	3.76	71.14
Stenotomus caprinus	456	3.45	74.59
Upeneus parvus	348	2.63	77.22
Centropristis philadelphica	285	2.16	79.38
Anchoa hepsetus	273	2.06	81.44
Non-Dominant Species (58)			
Saurida brasiliensis	227	1.72	83.16
Porichthys porosissimus	211	1.60	84.76
Trichiurus lepturus	204	1.54	86.30
Synodus foetens	198	1.50	87.80
Halieutichthys aculeatus	189	1.43	89.23
Trachurus lathami	170	1.29	90.52
Lepophidium graellsi	161	1.22	91.74
Etropus crossotus	144	1.09	92.83
Sphoeroides parvus	100	0.76	93.59
Peprilus paru	88	0.67	94.26
Ogcocephalus sp.	67	0.51	94.77
Bollmania communis	66	0.50	95.27
Harengula jaguana	64	0.48	95.75
Lagocephalus laevigatus	63	0.48	96.23
Symphurus civitatus	62	0.47	96.70
Citharichthys spilopterus	56	0.42	97.12
Micropogonias undulatus	51	0.39	97.51
Lutjanus campechanus	38	0.29	97.80
Priacanthus arenatus	34	0.26	98.06
Urophycis floridanus	29	0.22	98.28
Gymnachirus texae	26	0.20	98.48
Engyophrys senta	24	0.18	98.66
Selene setapinnis	23	0.17	98.83
Bregmaceros atlanticus	19	0.14	98.97
Opisthonema oglinum	16	0.12	99.09
Etrumeus teres	13	0.10	99.19
Leiostomus xanthurus	11	0.08	99.27
Cyclopsetta chittendeni	10	0.08	99.35
Menticirrhus americanus	10	0.08	99.43
Scomberomorus cavalla	9	0.07	99.50
Prionotus salmonicolor	7	0.05	99.55
Prionotus tribulus	6	0.05	99.60

Appendix Table 7-4 (Continued).

Gymnothorax nigromarginatu	6	0.05	99.65
Rhizoprionodon terraenovae	5	0.04	99.69
Sphyraena guachancho	5	0.04	99.73
Anchoa mitchilli	5	0.04	99.77
Paralichthyd lethostigma	3	0.02	99.79
Orthopristis chrysoptera	3	0.02	99.81
Prionotus ophryas	3	0.02	99.83
Anchoa lyolepis	3	0.02	99.84
Scorpaena calcarata	3	0.02	99.86
Ancylopsetta quadrocellata	2	0.02	99.87
revoortia patronus	2	0.02	99.89
Sphyrna tiburo	2	0.02	99.90
Sardinella aurita	2	0.02	99.91
Caranx crysos	1	0.01	99.92
Stephanolepis hispidus	1	0.01	99.92
Opichthus gomesi	1	0.01	99.93
Eucinostomus gula	1	0.01	99.94
Paralichthys albigutta	1	0.01	99.94
Chaetodipterus faber	1	0.01	99.95
Dasyatis americanus	1	0.01	99.96
Urophycis cirratus	1	0.01	99.97
Scomber japonicus	1	0.01	99.97
Ancylopsetta dilecta	1	0.01	99.98
Synodus poeyi	1	0.01	99.99
Syngnathus louisianae	1	0.01	99.99
Scomberomorus masculatus	1	0.01	100.00
TOTAL	13,224		

Appendix Table 7-5. Trends by Station in the Mean Catch of Shrimp and Mean Catch of Fish, October 1977 - February 1980.

		Shrimp		Fish	
Station	Tows	Catch	Avg/Tow	Catch	Avg/Tow
A	44	5,547	126.1	77,910	1,770.5
1	54	3,493	64.7	75,263	1,393.8
2	53	2,208	41.7	29,697	560.3
3	65	2,157	33.2	32,598	501.5
4	15	730	48.7	4,277	285.1
5	61	2,313	37.9	35,748	586.0
6	61	2,142	35.1	27,754	455.0
7	15	720	48.0	4,559	303.9
8	62	2,191	35.3	31,003	500.0
9	54	938	17.4	18,365	340.1
10	54	1,110	20.6	21,958	406.6
11	54	746	13.8	24,617	455.9
12	53	649	12.2	14,635	276.1
13	7	95	13.6	1,963	280.4
14	54	971	18.0	30,491	564.6
15	42	749	17.8	17,619	419.5
16	46	724	15.7	19,288	419.3
17	54	914	16.9	27,285	505.3
18	40	849	21.2	15,981	399.5
19	43	853	19.8	16,365	380.6
20	46	1,210	26.3	19,659	427.4
21	44	950	21.6	16,674	379.0
22	44	821	18.7	18,636	423.5
23	45	1,137	25.3	20,366	452.6
24	40	883	22.1	18,927	473.2
25	41	963	23.5	18,389	448.5
26	42	1,154	27.5	13,572	323.1

Appendix Table 7-6. Monthly Trends in the Total Abundance of Shrimp by Area, October 1977 - January 1980.

Cruise	Inshore			Offshore		
	Number of Tows	Total Catch	Mean	Number of Tows	Total Catch	Mean
Oct. 77, D	9	1,400	155.6	-	-	-
Nov. 77, D	16	1,142	71.4	-	-	-
Dec. 77, D	16	1,985	124.1	3	40	13.3
Feb. 78, D	16	177	11.1	3	2	0.7
Mar. 78, D	16	374	23.4	3	0	0.0
Apr. 78, D	16	54	3.4	3	2	0.7
May 78, D	16	130	8.1	3	3	1.0
June 78, D	16	309	19.3	3	0	0.0
July 78, D	11	369	33.6	3	25	8.3
Sep. 78, D	11	406	36.9	3	5	1.7
Oct. 78, D	-	-	-	3	0	0.0
Oct. 78, N	7	397	56.7	3	71	23.7
Dec. 78, N	16	2,095	130.9	6	417	69.5
Dec. 78, D	12	943	78.6	5	32	6.4
Feb. 79, D	11	60	5.5	6	0	0.0
Mar. 79, N	2	28	14.0	6	123	20.5
Apr. 79, N	16	138	8.6	6	103	17.2
Apr. 79, D	16	152	9.5	6	3	0.5
May 79, N	16	444	27.8	6	113	18.8
June 79, N	14	902	64.4	6	360	60.0
June 79, D	16	756	47.3	6	45	7.5
July 79, N	14	282	20.1	6	432	72.0
July 79, D	16	61	3.8	6	16	2.7
Aug. 79, D	16	965	60.3	-	-	-
Sep. 79, D	15	1,189	79.3	6	5	0.8
Oct. 79, N	16	674	42.1	6	215	35.8
Oct. 79, D	16	980	61.3	6	9	1.5
Nov. 79, N	16	1,100	68.8	6	195	32.5
Nov. 79, D	16	545	34.1	6	27	4.5
Dec. 79, N	16	595	37.2	6	92	15.3
Dec. 79, D	16	872	54.5	6	5	0.8
Jan. 80, N	16	1,405	87.8	6	74	12.3
Jan. 80, D	16	329	20.6	6	5	0.8
Σ	458	21,258	46.4	149	2,419	16.2

Appendix Table 7-7. Monthly Trends in the Total Abundance of Fish by Area, October 1977-January 1980.

	Inshore			Offshore		
Cruise	Number of Tows	Total Catch	Mean	Number of Tows	Total Catch	Mean
Oct. 77, D	9	8,936	992.9	-	-	-
Nov. 77, D	16	8,534	533.4	-	-	-
Dec. 77, D	16	4,517	282.3	3	1,211	403.7
Feb. 78, D	16	2,047	127.9	3	274	91.3
Mar. 78, D	16	2,331	145.7	3	335	111.7
Apr. 78, D	16	7,176	448.5	3	394	131.3
May 78, D	16	3,294	205.9	3	263	87.7
June 78, D	16	1,749	109.3	3	880	293.3
July 78, D	11	19,394	1,763.1	3	1,352	450.7
Sep. 78, D	11	7,063	642.1	3	555	185.0
Oct. 78, D	-	-	-	3	761	253.7
Oct. 78, N	7	6,714	959.1	3	2,758	919.3
Dec. 78, N	16	4,756	297.3	6	3,500	583.3
Dec. 78, D	12	2,927	243.9	5	1,808	361.6
Feb. 79, D	11	3,650	331.8	6	344	57.3
Mar. 79, N	2	280	140.0	6	2,939	489.8
Apr. 79, N	16	2,134	133.4	6	2,318	386.3
Apr. 79, D	16	7,082	442.6	6	1,157	192.8
May 79, N	16	9,305	581.6	6	2,696	449.3
June 79, N	14	21,474	1,533.9	6	3,930	655.0
June 79, D	16	25,999	1,624.9	6	7,807	1,301.2
July 79, N	14	13,659	975.6	6	5,118	853.0
July 79, D	16	9,628	601.8	6	3,279	546.5
Aug. 79, D	16	79,735	4,983.4	-	-	-
Sep. 79, D	15	9,784	652.3	6	4,615	769.2
Oct. 79, N	16	7,347	459.2	6	1,872	312.0
Oct. 79, D	16	4,258	266.1	6	1,707	284.5
Nov. 79, N	16	3,249	203.1	6	1,205	200.8
Nov. 79, D	16	4,282	267.6	6	869	144.8
Dec. 79, N	16	2,660	166.3	6	1,480	246.7
Dec. 79, D	16	2,152	134.5	6	736	122.7
Jan. 80, N	16	11,123	695.2	6	1,315	219.2
Jan. 80, D	16	4,198	262.4	6	934	155.7
Σ	458	301,437	658.2	149	58,412	392

Appendix Table 7-8. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during January. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1980	1980
Species	Night	Day
Cynoscion nothus	79	7
Cynoscion arenarius	4	21
Micropogonius undulatus	6	19
Anchoa mitchilli	--	17
Trichiurus lepturus	--	10
Larimus fasciatus	--	6
Peprilus burti	--	6
Leiostomus xanthurus	--	3

B. Offshore Area	1980	1980
Species	Night	Day
Stenotomus caprinus	58	53
Syacium gunteri	10	7
Synodus foetens	2	9
Saurida brasiliensis	5	--
Diplectrum bivittatum	4	3
Trachurus lathami	3	--
Priacanthus arenatus	3	--
Lutjanus campechanus	2	2
Upeneus parvus	2	--
Centropristis philadelphica	2	--
Serranus atrobranchus	2	--
Prionotus paralatus	2	--

C. Diffuser Area	1980	1980
Species	Night	Day
Cynoscion nothus	79	59
Peprilus burti	--	31
Syacium gunteri	11	6

Appendix Table 7-9. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during February. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1980	1978, 79, 80
Species	Night	Day
Micropogonias undulatus	46	3, --, 72
Anchoa mitchilli	6	62, 40, --
Leiostomus xanthurus	--	19, 36, --
Cynoscion nothus	35	3, 5, 4
Larimus fasciatus	3	--, --, 10
Cynoscion arenarius	3	2, 9, 3
Bairdiella chrysoura	--	5, --, --
Menticirrhus americanus	--	--, 4, 3

B. Offshore Area	1980	1978, 79, 80
Species	Night	Day
Stenotomus caprinus	53	22, 33, 36
Anchoa mitchilli	--	40, 00, 00
Etrumeus teres	--	--, 19, 00
Synodus foeteus	2	11, --, 12
Anchoa hepsotus	--	--, 12, --
Syacium gunteri	11	5, 2, 9
Saurida brasiliensis	--	9, --, 9
Sphoeroides parvus	2	--, 9, --
Diplectrum bivittatum	5	3, 8, 7
Peprilus burti	--	--, 8, 4
Lutjanus campechanus	3	--, --, 7
Trachurus lathami	--	--, 4, 3
Serranus atrobranchus	-	--, --, 4
Lepophidium graellsi	3	--, --, --

C. Diffuser Area	1980	1978, 79
Species	Night	Day
Cynoscion nothus	90	33, 29
Peprilus burti	2	21, 65
Syacium gunteri	4	18, 3
Etropus crossotus	--	7, --
Saurida brasiliensis	--	6, --
Trichiurus lepturus	--	3, --
Anchoa hepsetus	--	2, --

Appendix Table 7-10. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during March. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1979, 80	1979, 80
Species	Night	Day
Micropogonias undulatus	--, 65	5, 46
Cynoscion nothus	47, 14	50, 24
Stellifer lanceolatus	--, --	2, 18
Trichiurus lepturus	--, --	16, --
Cynoscion arenarius	--, 3	15, 4
Syacium gunteri	14, --	--, --
Lepophidium graellsi	9, --	--, --
Etropus crossotus	6, --	--, --
Ariopsis felis	--, 6	--, --
Centropristis philadelphica	5, --	--, --
Saurida brasiliensis	4, --	--, --
Larimus fasciatus	--, 4	--, --
Anchoa mitchilli	--, --	4, --
Symphurus civitatus	2, --	--, --
Serraniculus pumilio	2, --	--, --

B. Offshore Area	1979, 80	1979, 80
Species	Night	Day
Chloroscombrus chrysurus	--, --	67, 5
Stenotomus caprinus	52, 36	2, 50
Cynoscion nothus	--, 30	--, --
Peprilus burti	--, --	10, 18
Sphoeroides parvus	--, 11	2, --
Syacium gunteri	9, 7	--, 2
Anchoa hepsetus	--, --	--, 8
Diplectrum bivittatum	7, --	3, 5
Trachurus lathami	--, --	7, 4
Prionotus paralatus	6, --	--, --
Synodus foetens	--, --	3, 4
Centropristis philadelphica	4, --	--, --
Cynoscion arenarius	3, --	--, --
Synodus poeyi	2, --	--, --
Scorpaena calcarata	2, --	--, --

C. Diffuser Area	1979, 80	1980
Species	Night	Day
Cynoscion nothus	39, 74	72
Syacium gunteri	15, 10	10

(continued)

Appendix Table 7-10 (continued).

C. Diffuser Area (Cont'd)	1979, 80	1980
Species	Night	Day
Peprilus burti	12, --	8
Saurida brasiliensis	8, --	--
Etropus crossotus	6, --	--
Halieutichthys aculeatus	--, 5	--
Centropristis philadelphica	5, --	--
Lepophidium graellsi	4, --	--
Cynoscion arenarius	3, --	4
Symphurus civitatus	--, --	--

Appendix Table 7-11. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during April. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1979, 80	1978, 79, 80
Species	Night	Day
Micropogonias undulatus	11, 75	--, 7, 40
Anchoa mitchilli	7, --	46, 2, --
Cynoscion nothus	22, 18	8, 19, 42
Peprilus burti	3, --	27, 10, —
Trichiurus lepturus	6, —	9, 18, --
Menticirrhus americanus	17, —	—, 7, --
Stellifer lanceolatus	10, 2	--, 4, 8
Larimus fasciatus	9, 2	--, 5, --
Chloroscombrus chrysurus	--, --	--, 8, --
Ariopsis felis	--, --	--, 7, --
Brevoortia patronus	--, --	—, 5, --
Cynoscion arenarius	4, —	--, --, —
Harengula jaguana	--, --	4, --, —
Anchoa hepsetus	—, --	2, --, —
Engraulis eurystole	—, --	--, --, 2
Prionotus tribulus	2, --	--, --, —

B. Offshore Area	1979, 80	1978, 79, 80
Species	Night	Day
Stenotomus caprinus	49, 53	18, 21, 44
Chloroscombrus chrysurus	—, --	—, 33, —
Trachurus lathami	--, --	5, 21, 9
Saurida brasiliensis	--, --	17, --, 6
Diplectrum bivittatum	9, 15	16, 4, 9
Synodus foetens	—, 2	16, --, 7
Syacium gunteri	9, 7	14, --, 3
Anchoa hepsetus	—, --	--, 8, --
Lutjanus campechanus	--, --	—, —, 7
Centropristis philadelphica	5, --	--, --, —
Peprilus burti	—, --	--, 5, --
Sphoeroides parvus	2, 3	--, --, --
Scorpaena calcarata	3, --	--, --, --
Prionotus paralatus	3, --	3, --, --
Cynoscion arenarius	—, 3	—, --, —
Priacanthus arenatus	—, --	—, --, 2
Serranus atrobranchus	--, --	--, —, 2
Synodus poeyi	--, --	2, --, —

(continued)

Appendix Table 7-11 (continued).

C. Diffuser Area	1979, 80	1979, 80
Species	Night	Day
Cynoscion nothus	40, 88	15, --
Engraulis eurystole	--, --	--, 54
Chloroscombrus chrysurus	--, --	44, 28
Peprilus burti	2, --	11, --
Syacium gunteri	9, 3	--, --
Anchoa hepsetus	3, --	10, --
Trichiurus lepturus	3, --	9, --
Etropus crossotus	9, --	--, --
Trachurus lathami	--, --	--, 6
Urophycis floridanus	5, --	--, --
Cynoscion arenarius	5, --	--, --
Harengula jaguana	--, --	3, --
Symphurus civitatus	3, --	--, --
Urophycis cirratus	3, --	--, --
Scomber japonicus	--, --	--, 3
Halieutichthys aculeatus	2, --	--, --
Centropristis philadelphica	2, --	--, --
Diplectrum bivittatum	--, --	2, --

Appendix Table 7-12. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during May. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1979, 80	1978, 80
Species	Night	Day
Micropogonias undulatus	54, 56	10, 70
Chloroscombrus chrysurus	--, --	23, 7
Peprilus burti	--, --	18, --
Cynoscion nothus	3, 17	17, 8
Cynoscion arenarius	11, --	--, --
Anchoa mitchilli	--, --	9, --
Stellifer lanceolatus	--, 7	8, 5
Larimus fasciatus	6, 7	--, --
Menticirrhus americanus	6, --	--, --
Prionotus tribulus	4, --	--, --
Trichurus lepturus	--, --	5, --
Leiostomus xanthurus	3, --	--, --
Anchoa hepsetus	--, 3	3, --
Ariopsis felis	2, --	--, --

B. Offshore Area	1979, 80	1978, 79
Species	Night	Day
Chloroscombrus chrysurus	--, --	29, 86
Syacium gunteri	29, 2	13, --
Lutjanus campechanus	--, 18	3, --
Stenotomus caprinus	14, 16	--, --
Prionotus paralatus	--, 12	--, --
Diplectrum bivittatum	11, 8	5, --
Trichiurus lepturus	--, --	10, --
Anchoa hepsetus	--, --	8, --
Peprilus burti	--, --	7, --
Scorpaena calcarata	8, --	--, --
Centropristis philadelphica	6, 7	--, --
Sphoeroides parvus	3, 7	--, --
Saurida brasiliensis	--, 6	--, --
Harengula jaguana	--, --	6, --
Pristipomoides aquilonaris	3, 5	--, --
Trachurus lathami	--, --	4, 4
Synodus foeteus	--, 3	--, 3
Porichthys porosissimus	3, --	--, --
Bregmaceros atlanticus	--, 3	--, --
Lagodon rhomboides	3, --	--, --
Opisthonema oglinum	--, --	2, --
Engyophrys senta	2, --	--, --

(continued)

Appendix Table 7-12 (continued)

C. Diffuser Area	1979, 80	1980
Species	Night	Day
Chloroscombrus chrysurus	—, —	71
Stenotomus caprinus	—, 38	—
Diplectrum bivittatum	23, 9	—
Syacium gunteri	20, 7	—
Cynoscion arenarius	17, —	—
Peprilus burti	—, —	15
Priacanthus arenatus	9, —	—
Prionotus rubio	4, 9	—
Centropristis philadelphica	2, 8	—
Saurida brasiliensis	—, 8	—
Porichthys porosissimus	6, —	—
Bregmaceros atlanticus	—, 4	—
Anchoa hepsetus	—, —	3
Cynoscion nothus	—, —	3
Lepophidium graellsi	3, 2	—
Etropus crossotus	3, —	—
Halieutichthys aculeatus	2, —	—
Trichiurus lepturus	—, —	2
Anchoa lyolepis	—, 2	—
Upeneus parvus	—, 2	—

Appendix Table 7-13. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during June. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1979, 80	1978, 79, 80
Species	Night	Day
Micropogonias undulatus	49, 86	14, 20, 84
Stellifer lanceolatus	35, 2	—, 39, —
Harengula jaguana	—, —	29, —, —
Cynoscion nothus	—, —	19, 8, 5
Brevoortia patronus	—, —	—, 9, —
Trichiurus lepturus	—, —	8, —, —
Cynoscion arenarius	5, —	7, 4, —
Peprilus burti	—, —	6, —, —
Ariopsis felis	—, —	—, 6, —
Chloroscombrus chrysurus	4, —	5, 5, 4
Leiostomus xanthurus	—, —	—, 4, -
Prionotus rubio	—, 3	—, —, —
Larimus fasciatus	—, 3	—, 2, —
Peprilus paru	—, —	2, —, —

B. Offshore Area	1979, 80	1978, 79, 80
Species	Night	Day
Stenotomus caprinus	7, 30	27, 4, 39
Syacium gunteri	28, —	6, 7, 9
Trachurus lathami	—, —	28, 26, 19
Saurida brasiliensis	—, 4	4, 14, 7
Prionotus paralatus	3, 11	4, —, 3
Priacanthus arenatus	—, —	—, 11, —
Etrumeus teres	—, 10	—, —, —
Engraulis eurystole	—, 10	—, —, —
Upeneus parvus	8, —	—, 10, 3
Diplectrum bivittatum	9, —	—, 5, 3
Anchoa lyolepis	—, 8	3, —, —
Anchoa hepsetus	—, 7	—, —, —
Sphoeroides parvus	6, 4	—, —, —
Porichthys porosissimus	5, —	—, —, —
Scorpaena calcarata	5, —	—, —, —
Chloroscombrus chrysurus	—, —	—, 5, —
Synodus foetens	2, —	3, 2, 3
Centropristis philadelphica	3, 2	—, —, 3
Peprilus burti	—, —	2, 5, 3
Prionotus stearnsi	—, 3	2, —, —
Prionotus rubio	3, —	—, —, —
Lutjanus campechanus	—, —	2, —, —
Engyophrys senta	2, -	—, —, —
Synodus poeyi	—, —	2, —, —

(continued)

Appendix Table 7-13 (continued).

C. Diffuser Area	1979, 80	1979, 80
Species	Night	Day
Peprilus burti	--, 5	35, 28
Cynoscion arenarius	30, --	16, —
Chloroscombrus chrysurus	—, —	28, 6
Prionotus rubio	24, 28	—, --
Centropristis philadelphica	--, 22	--, --
Anchoa lyolepis	--, --	--, 16
Cynoscion nothus	—, 12	3, --
Syacium gunteri	13, 11	--, 2
Engraulis eurystole	—, --	--, 11
Anchoa hepsetus	--, --	--, 10
Trachurus lathami	--, --	9, 5
Etrumeus teres	--, --	--, 8
Diplectrum bivittatum	6, --	--, --
Stenotomus caprinus	--, --	--, 6
Halieutichthys aculeatus	5, --	--, --
Saurida brasiliensis	—, —	--, 4
Citharichthys spilopterus	--, 4	--, --
Porichthys porosissimus	3, --	--, --
Peprilus paru	--, --	2, --
Lepophidium graellsi	—, 2	--, --

Appendix Table 7-14. Principal species and percentages of fishes captured in the inshore, offshore and diffuser areas during July. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1978, 79, 80	1978, 79, 80
Species	Night	Day
Micropogonias undulatus	--, 32, 72	7, 26, 31
Stellifer lanceolatus	--, 30, 7	--, 48, --
Chloroscombrus chrysurus	--, 4, --	2, 6, 37
Trachurus lathami	--, --, --	32, --, --
Ariopsis felis	--, 18, --	--, --, --
Anchoa hepsetus	--, --, --	16, --, --
Peprilus paru	--, --, --	16 --, --
Peprilus burti	--, --, --	11, --, --
Cynoscion nothus	--, --, 2	3, 6, 10
Brevoortia patronus	--, 4, --	--, 5, --
Menticirrhus americanus	--, 5, --	--, --, --
Prionotus rubio	--, --, 4	--, --, --
Trichiurus lepturus	--, --, --	--, --, 4
Cynoscion arenarius	--, 3, --	4, --, --
Stenotomus caprinus	--, --, 4	3, --, --
Leiostomus xanthurus	--, --, 2	2, --, --
Larimus fasciatus	--, --, 2	--, 2, --

B. Offshore Area	1979, 80	1978, 79, 80
Species	Night	Day
Stenotomus caprinus	9, 60	46, --, 6
Trachurus lathami	--, --	41, 5, 17
Anchoa hepsetus	--, --	--, --, 39
Upeneus parvus	24, --	--, 12, --
Prionotus rubio	3, --	--, 18, --
Syacium gunteri	17, 5	--, 17, --
Sardinella aurita	--, --	--, --, 11
Diplectrum bivittatum	9, 2	--, --, --
Peprilus burti	--, --	--, 8, --
Cynoscion arenarius	8, --	--, 4, --
Sphoeroides parvus	3, 7	--, --, --
Centropristis philadelphica	--, 7	--, 4 --
Engraulis eurystole	--, --	--, --, 6
Chloroscombrus chrysurus	--, --	--, --, 6
Porichthys porosissimus	5, --	--, --, --
Synodus foetens	--, --	4, 5, --
Anchoa lyolepis	--, --	--, --, 5
Saurida brasiliensis	--, --	--, 4, --
Etropus crossotus	--, --	--, 4, --

Appendix Table 7-14 (continued).

B. Offshore Area (cont'd)	1979, 80	1978, 79, 80
Species	Night	Day
Lagocephalus laevigatus	—, --	--, 3, --
Priacanthus arenatus	--, --	--, 3, --
Harengula jaguana	--, --	--, --, 3
Prionotus paralatus	2, 3	--, --, --
Lepophidium graellsi	3, --	--, —, --
Trichiurus lepturus	—, --	--, 2, --

C. Diffuser Area	1979, 80	1978, 79, 80
Species	Night	Day
Chloroscombrus chrysurus	--, --	--, --, 88
Trachurus lathami	--, --	48, --, --
Lepophidium graellsi	44, --	--, --, --
Sphoeroides parvus	—, 37	--, —, --
Prionotus rubio	34, 4	--, --, --
Anchoa hepsetus	--, --	33, --, —
Stenotomus caprinus	--, 30	—, --, 6
Anchoa lyolepis	--, --	11, --, --
Saurida brasiliensis	--, 10	--, --, --
Centropristis philadelphica	6, 9	—, --, --
Etrumeus teres	--, --	4, --, --
Peprilus burti	—, 3	--, --, --
Serranus subligarius	3, --	—, --, --
Serraniculus pumulio	2, --	--, --, --
Porichthys porosissimus	2, --	--, --, --

Appendix Table 7-15. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during August. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1980	1979, 80
Species	Night	Day
Chloroscombrus chrysurus	44	83, 89
Micropogonias undulatus	29	10, —
Stellifer lanceolatus	6	--, --
Stenotomus caprinus	--	--, 4
Prionotus rubio	3	--, --
Anchoa mitchilli	3	--, --
Cynoscion arenarius	2	--, --
Sphoeroides parvus	2	--, --

B. Offshore Area	1980	1980
Species	Night	Day
Clororscombrus chrysurus	--	89
Stenotomus caprinus	59	--
Micropogonias undulatus	16	--
Trichiurus lepturus	--	5
Prionotus rubio	4	--
Halieutichthys aculeatus	3	--
Diplectrum bivittatum	3	--
Sphoeroides parvus	3	--
Peprilus burti	--	2

C. Diffuser Area	1980	1979, 80
Species	Night	Day
Chloroscombrus chrysurus	--	80, 85
Micropogonias undulatus	47	—, 5
Prionotus rubio	18	--, --
Stenotomus caprinus	8	--, 2
Leiostomus xanthurus	--	6, —
Cynoscion nothus	3	5, —
Anchoa hepsetus	4	--, 2
Larimus fasciatus	3	--, --
Sphoeroides parvus	2	--, --
Harengula jaguana	—	2, --
Anchoa lyolepis	--	--, 2

Appendix Table 7-16. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during September. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1978, 1979
Species	Day
Chloroscombrus chrysurus	67, 19
Micropogonias undulatus	6, 24
Ariopsis felis	--, 13
Cynoscion arenarius	3, 8
Cynoscion nothus	7, 2
Harengula jaguana	5, 0
Trichiurus lepturus	--, 5
Stellifer lanceolatus	--, 4
Polydactylus octonemus	3, 2
Peprilus paru	3, --
Peprilus burti	--, 2
Porichthys porosissimus	--, 2
Menticirrhus americanus	--, 2
Prionotus rubio	--, 2

B. Offshore area	1978, 1979
Species	Day
Chloroscombrus chrysurus	--, 44
Peprilus burti	26, 9
Stenotomus caprinus	23, 12
Trachurus lathami	12, 5
Anchoa hepsetus	10, --
Upeneus parvus	--, 9
Syacium gunteri	3, 5
Synodus foetens	5, --
Lagodon rhomboides	4, 4
Priacanthus arenatus	--, 3
Pareques umbrosus	2, --

C. Diffuser Area	1978, 1979
Species	Day
Chloroscombrus chrysurus	22, 65
Anchoa hepsetus	25, --
Micropogonias undulatus	10, 8
Harengula jaguana	10, --
Peprilus burti	8, --
Cynoscion nothus	7, 7
Opisthonema oglinum	5, --

(continued)

Appendix Table 7-16 (continued).

C. Diffuser Area (cont'd) 1978, 1979

Species	Day
Syacium gunteri	--, 5
Peprilus paru	3, --
Prionotus rubio	--, 3
Diplectrum bivittatum	3, --

Appendix Table 7-17. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during October. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1978, 79	1977, 78, 79
Species	Night	Day
Chloroscombrus chrysurus	45, --	--, --, 2
Cynoscion nothus	38, 11	8, --, 27
Micropogonias undulatus	--, 22	37, --, 12
Stellifer lanceolatus	--, 22	13, --, 7
Peprilus burti	--, --	20, --, --
Trichiurus lepturus	--, --	--, --, 15
Ariopsis felis	--, 11	--, --, 5
Anchoa mitchilli	--, --	--, --, 10
Cynoscion arenarius	--, --	--, --, 8
Porichthys porosissimus	4, 7	--, --, --
Prionotus rubio	--, 6	--, --, --
Stenotomus caprinus	--, 5	--, --, --
Syacium gunteri	3, --	--, --, --
Polydactylus octonemus	--, --	3, --, --
Centropristis philadelphica	--, 2	--, --, --

B. Offshore Area	1978, 79	1978, 79
Species	Night	Day
Chloroscombrus chrysurus	61, 4	72, 20
Stenotomus caprinus	8, 31	--, 28
Syacium gunteri	6, 10	15, 3
Upeneus parvus	--, 9	--, 14
Trachurus lathami	--, --	2, 11
Micropogonias undulatus	--, 8	--, --
Diplectrum bivittatum	7, 3	4, 2
Leiostomus xanthurus	2, 6	--, --
Peprilus burti	--, --	--, 5
Serranus atrobranchus	2, 4	--, --
Lagocephalus laevigatus	--, 4	--, --
Synodus foetens	--, --	--, 3
Pristipomoides aquilonaris	--, 3	--, --
Centropristis philadelphica	--, 2	--, --
Priacanthus arenatus	--, 2	--, --

C. Diffuser Area	1978, 79	1978, 79
Species	Night	Day
Stenotomus caprinus	--, 65	--, --
Chloroscombrus chrysurus	20, 2	54, 56
Anchoa hepsetus	--, --	31, 3

(continued)

Appendix Table 7-17 (continued).

C. Diffuser Area (cont'd)	1978, 79 Night	1978, 79 Day
Species		
Syacium gunteri	27, 7	7, 4
Cynoscion nothus	13, --	—, 14
Diplectrum bivittatum	13, —	—, --
Prionotus rubio	3, 7	—, 3
Upeneus parvus	--, 5	—, —
Sphoeroides parvus	5, --	--, --
Cynoscion arenarius	--, --	--, 4
Porichthys porosissimus	3 3	—, —
Lutjanus campechanus	2, --	--, --
Lepophidium graellsi	--, 2	--, --
Anchoa lyolepis	—, —	2, --
Centropristis philadelphica	2, --	--, --
Trichiurus lepturus	--, --	--, 2

Appendix Table 7-18. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during November. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1979	1977, 79
Species	Night	Day
Cynoscion nothus	49	41, 7
Anchoa hepsetus	--	9, 30
Peprilus burti	--	7, 24
Harengula jaguana	--	16, --
Anchoa mitchilli	2	15, 9
Ariopsis felis	13	--, -
Stellifer lanceolatus	12	--, 5
Cynoscion arenarius	8	--, 3
Micropogonias undulatus	4	4, --
Chloroscombrus chrysurus	--	--, 4
Trichiurus lepturus	--	3, 4
Anchoa lyolepis	--	--, 4
Bagre marinus	--	--, 2

B. Offshore Area	1979	1979
Species	Night	Day
Stenotomus caprinus	48	18
Syacium gunteri	8	19
Saurida brasiliensis	--	14
Upeneus parvus	7	5
Micropogonias undulatus	6	--
Synodus foetens	--	6
Upeneus parvus	--	--
Prionotus rubio	4	5
Diplectrum bivittatum	3	4
Pristipomoides aquilonaris	--	4
Chloroscombrus chrysurus	--	4
Prionotus salmonicolor	3	--
Halieutichthys aculeatus	--	3
Synodus poeyi	--	2
Cyclopsetta chittendeni	--	2
Centropristis philadelphica	2	--
Sphoeroides parvus	2	--

C. Diffuser Area	1979	1979
Species	Night	Day
Cynoscion nothus	38	23
Trachurus lathami	--	19
Syacium gunteri	18	16

(continued)

Appendix Table 7-18 (continued)

C. Diffuser Area (cont'd)	1979	1979
Species	Night	Day
Ariopsis felis	10	--
Chloroscombrus chrysurus	--	9
Centropristis philadelphica	9	2
Porichthys porosissimus	6	--
Saurida brasiliensis	--	5
Peprilus burti	--	4
Prionotus rubio	4	3
Lepophidium graellsi	3	--
Synodus foetens	--	3
Cynoscion arenarius	--	3
Sphoeroides parvus	3	--
Upeneus parvus	--	3

Appendix Table 7-19. Principal species and percentages of fishes captured in the inshore, offshore, and diffuser areas during December. Years when cruises were made are indicated for each area. Dash symbols represent percentages lower than 2%.

A. Inshore Area	1978, 79	1977, 78, 79
Species	Night	Day
Cynoscion arenarius	6, 50	2, 26, 27
Cynoscion nothus	34, 28	37, 8, 6
Micropogonias undulatus	—, —	6, —, 29
Stellifer lanceolatus	18, 3	13, 16, 20
Anchoa mitchilli	—, —	16, 16, —
Menticirrhus americanus	9, —	—, 12, 3
Etropus crossotus	6, —	—, 3, —
Brevoortia patronus	—, 3	—, —, —
Syacium gunteri	3, —	7, —, —
Larimus fasciatus	2, —	—, —, 3
Chloroscombrus chrysurus	2, 2	6 —, —
Orthopristis chrysoptera	—, —	—, 3 —
Centropristis philadelphica	2, —	—, —, —
Prionotus tribulus	—, —	—, 2, —
Porichthys porosissimus	2, —	—, —, —

B. Offshore Area	1978, 79	1977, 78, 79
Species	Night	Day
Stenotomus caprinus	19, 65	20, 50, 32
Syacium gunteri	29, 3	31, 16, 13
Diplectrum bivittatum	16, —	11, 10 3
Upeneus parvus	—, 6	—, —, 15
Synodus foetens	—, —	7, 5, 7
Sauirda brasiliensis	—, —	6, 4, 4
Prionotus paralatus	4, —	—, 3, 3
Lutjanus campechanus	—, 2	4, —, —
Lagodon rhomboides	—, 4	—, —, —
Porichthys porosissimus	4, —	—, —, —
Centropristis philadelphica	3, 2	—, —, —
Micropogonias undulatus	3, —	—, —, —
Synodus poeyi	-, —	3, —, —
Serranus atrobranchus	2, —	-, —, 3
Pristipomoides aquilonaris	—, —	2, —, 2
Sphoeroides parvus	2, —	3, —, —
Lagocephalus laevigatus	—, —	—, —, 2
Peprilus burti	—, —	—, —, 2
Chloroscombrus chrysurus	—, —	—, —, 2

(continued)