



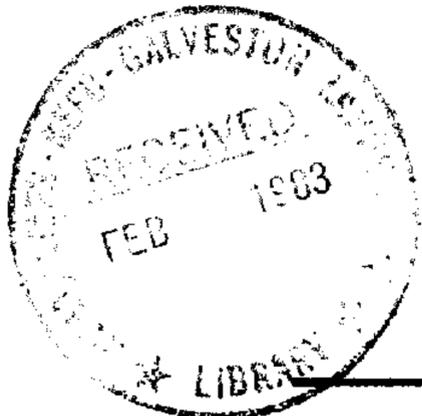
NOAA Technical Memorandum NMFS-SEFC-104

Three Reports Concerning the Tortugas Sanctuary Studies, 1981-1982

Report I. The Tortugas Sanctuary Study, May 1981-February 1982; Edward F. Klima and Thomas Costello.

Report II. A Preliminary Analysis of Pink Shrimp (*Penaeus duorarum*) Size and Abundance During the Tortugas Shrimp Sanctuary Study, September 1981-February 1982; Terrell W. Roberts.

Report III. A Synopsis of the Tortugas Pink Shrimp Fishery, 1960-19681, and the Impact of the Tortugas Sanctuary; Edward F. Klima, Geoffrey A. Matthews, Frank J. Patella.



U. S. DEPARTMENT OF COMMERCE

Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration

Dr. John V. Byrne, Administrator

National Marine Fisheries Service

William G. Gordon, Assistant Administrator for Fisheries

DECEMBER 1982

Technical Memorandums are used for documentation and timely communication of preliminary results, interim reports, or special-purpose information, and have not received complete formal review, editorial control, or detailed editing.

REPORT I

THE TORTUGAS SANCTUARY STUDY

MAY 1981-FEBRUARY 1982

by

Edward F. Klima

Thomas Costello

INTRODUCTION

The Shrimp Fishery Management Plan for the Gulf of Mexico was implemented by the Secretary of Commerce on May 15, 1981. The Tortugas shrimp sanctuary was implemented concurrently on that date and regulations prohibited all trawling activity within that area. The objective of the Tortugas shrimp sanctuary is to optimize the yield of the shrimp recruited to the Tortugas fishery by establishing a cooperative closure with the State of Florida and the U.S. Department of Commerce to protect small shrimp until they have generally reached a size large than 69 tails/lb.* According to the plan, yield would be increased by protecting shrimp from fishing in an area where they were predominantly small and growing rapidly.

This overview report provides an evaluation of how well the objectives of the Tortugas shrimp sanctuary regulation were achieved in 1981. The overview report presents the results of the individual research studies that have been undertaken in connection with the Tortugas shrimp sanctuary. The individual research reports are listed in Appendix A of this report. These specific research papers should be referred to for a detailed description of the data obtained and analytical methods used. Appendix B of this report also contains a cost summary of the research studies.

The Gulf of Mexico Fishery Management Council (GMFMC) requested the Southeast Fisheries Center (SEFC), National Marine Fisheries Service, National Oceanic and Atmospheric Administration to plan and initiate a program of sampling from September 1981 through February 1982 to determine whether adjustments of the Tortugas sanctuary area might be necessary to delineate the Tortugas shrimp nursery area more

*70 shrimp/lb, heads off.

precisely. This report specifically addresses the following questions:

1. What is the regulatory history of the Tortugas pink shrimp fishery?
2. What are the characteristics of the Tortugas fishery in the period of research including catch, effort, catch per unit of effort (CPUE) and fleet mobility?
3. What are the size ranges of shrimp inside and outside the sanctuary area during the study period.?
4. What is the effectiveness of the sanctuary line in protecting small shrimp from fishing compared to selected alternative positions of the sanctuary line?

QUESTION 1: What is the regulatory history for the Tortugas pink shrimp fishery?

Historic

Commercial concentrations of pink shrimp were discovered in the Tortugas Florida area by fishermen Felix Salvador and Everett Peterson in 1949. A fishery was developed in 1950 and has ordinarily produced annual catches of 8-12 million lbs, heads off.* The fishery is primarily based on a single species, Penaeus duroraum. Other species occur in trawl catches, notably Trachypenaeus similis, T. constrictus, Solenocera atlantic, Penaeopsis quodei and some rock shrimp of the genus Sicyonia. These are of minor importance.

As early as 1955, widespread concern developed over the possibility that Tortugas pink shrimp, particularly small pink shrimp, were being overexploited. Most of the concern was expressed over large catches of very small shrimp which were not saleable and were therefore discarded at sea.

Studies by the Marine Laboratory of the University of Miami led to initial Tortugas management regulations enacted by the Florida State Board of Conservation in 1957. The 1957 session of the Florida legislature passed a law designating part of the Tortugas fishing grounds a "controlled area", i.e., an area that could be closed or open to shrimp trawling as appropriate (Figs 1 and 2). This "controlled area" is the forerunner of the present sanctuary (a sanctuary in various geographic forms has been in effect throughout the history of this fishery). The decision to open or close the "controlled area" was based on sizes of shrimp occurring in the area. When shrimp were predominantly smaller than 50 count, heads off, the area was to be

*Commercial landings are reported in lbs, heads off.

closed to trawling. In 1961 the Florida legislature modified the controlled area specifying one part to be permanently closed and designated a "nursery area". The remainder was designated as a controlled area to be opened or closed as appropriate based on sizes of shrimp in that area (Fig 3). An analysis of Tortugas shrimp sizes derived from sampling in the area is given by Ingle et al. (1959). A history of regulations relating to the Tortugas shrimp fishery is given by Costello (MS), and it has been discussed by Caillouet and Koi (1981) in the context of annual fluctuations in size composition of the catches from 1960 to 1978.

Deferred Harvest Rationale

Initially, the decision to establish a sanctuary for small pink shrimp in the Tortugas area was based on the assumption that deferred harvest of small pink shrimp would result in a benefit to the fishery. The background for the State of Florida management of the Tortugas fishery is clearly expressed in a letter of August 24, 1978 from Charles R. Futch to O. B. Lee. The letter in part stated "...We operate under the basic assumption that: it is desirable to catch the greatest possible number of pounds of shrimp, this desirability being enhanced as the sizes of shrimp are increased." The letter from Futch to Lee further explains Florida State management as follows: "...The shallow, brackish, grassy areas of Florida Bay serve as the nursery grounds for pink shrimp. As growth proceeds, shrimp seek progressively deeper water, resulting in west and northwesterly movements. A comparison of shrimp size with depth (Iversen, et al., 1960) demonstrated that, despite a size differential between sexes, size increased with increasing water depth. Females with a mean carapace length of 25 mm (corresponding to a count size of 67, heads on)

could be expected in depths of 7 fms or greater.

"Clearly, shrimp can be expected to be larger than 67-count/tails by the time they migrate into the open fishing area. The fact that the long northern leg of the line crosses the 7-fm contour presents no contradiction. Iversen et al. (1960) also noted a size gradient in a northerly direction irrespective of depth." The fact that Florida Bay estuaries serve as nursery areas for the Tortugas fishery was confirmed in a series of mark-recapture experiments (Costello and Allen, 1966).

Mortality Studies

Studies estimating rates of fishing and natural mortality for Tortugas pink shrimp (Costello and Allen, 1968; Berry, 1967; Parrack, 1980) supported the rationale for deferred harvest management of Tortugas pink shrimp. Lindner (1965) presented a clear summary of what we know about shrimp size and the Tortugas fishery. His paper further supports the view that protection of small shrimp would increase yield. Another study (Kutkuhn, 1966) did not support the rationale for deferred harvest management; however, mortality estimates in the study were based on small numbers of observations and possible bias in marking methods.¹

The Department of Commerce Fishery Management Plan enacted in 1981 established a cooperative Tortugas sanctuary closure designed to protect small pink shrimp until they have generally reached a size range larger than 69 tails/lb. This sanctuary slightly modified the historic sanctuary established by the state of Florida. The original "controlled area", its location relative to the Florida keys, the historic State of Florida shrimp sanctuary and the

¹Thomas Costello, Dept. of Commerce, NOAA, NMFS, SEFC, Miami, FL; personal communication.

current Tortugas sanctuary established in the Department of Commerce Shrimp Fishery Management Plan are shown in Figs 1, 2, 3 and 4.

QUESTION 2: What are the characteristics of the Tortugas fishery in the period of research including catch, effort, CPUE and fleet mobility? (This answer is based on information from Klima, et al. (MS)).

Commercial landings from statistical subareas 1, 2 and 3 in 1981 greatly exceeded landings in all of the years of the fishery since 1960. Average landings are approximately 10 million lbs/yr, heads off; however, in 1981 landings amounted to 14.5 million lbs of shrimp. The landings appeared to be stable during the 21-yr period with the exceptions of 1960 and 1981, which greatly exceeded the average and were larger than the standard deviation of this 21-year period (Fig 5).

The fishery basically begins each year in September/October with recruitment of small shrimp to the grounds with peak harvest in December, January and February and slight declines in March and April, tapering off considerably in the May-August period. It is evident that monthly landings in 1981 were markedly different than the monthly averages of the landings in the rest of the years (Figs 6 and 7).

Fishing effort did not fluctuate greatly over the 21-yr time frame and averaged 16.5 thousand days/yr. One fishing day is defined to be equivalent to 24 hrs of fishing time. Highest efforts were expended in 1961 and 1978. In 1981, the effort was below average but within one standard deviation of the 21-yr time span (Fig 8). Browder² indica-

²Browder, Joan; DOC, NOAA, NMFS, SEFC, Miami, FL; personal communication.

tes that 768 vessels trawled in the Tortugas-Sanibel grounds (subareas 1-4) in 1981. Over 72% of these vessels also trawled in other regions of the Gulf of Mexico that same year. The total activity of the fleet, according to the number of trips, reaches a peak in the winter in Tortugas-Sanibel and a peak in the summer in the rest of the Gulf of Mexico.

Furthermore, the relative abundance of pink shrimp as measured by CPUE for 24-hr fishing days is remarkably stable throughout the 1960-1979 period, with an average of 603 lbs/24-hr day (Fig 9). The highest CPUE occurred in 1981 with a catch of 957 lbs/24-hr day. There were significant differences in the CPUE between 1981 and all other years in the fishery. Further, when comparing fishing effort versus catch, the catch appears to be relatively stable for all years except 1960 and 1981 (Fig 10).

Size distribution in 1981 was significantly different from that in the last 5 years (1976-1980) and the first 5 years (1960-1964) of the fishery. The difference between 1981 and the other years was a major recruitment of 50-count or smaller shrimp onto the fishing grounds in March and April 1981. This recruitment could be followed by their modal size classes through August. Historically, there is not a large spring recruitment; however, 1981 was different and this recruitment was easily detectable in the size categories of the commercial landings. In October-December 1981, larger shrimp were landed than for a similar time period from 1976-1980.

The catch and relative abundance, as well as the size distribution of the shrimp on the Tortugas grounds, was different in 1981 from all other years of the fishery except perhaps 1960. Landings were higher, CPUE was higher, and major recruitment of small shrimp which could be followed

throughout the fishery for several months occurred in March and April. The newly-established sanctuary line may have protected the small shrimp during the months of May-September and may have resulted in larger shrimp being caught in October, November and December. Subsequent recruitments of small young-of-the-year shrimp in the fall of 1981 was probably not as great as in previous years.

Unfortunately, it is not possible to make a clear determination from these data that the differences observed in the commercial catch statistics were attributed to implementation of the Tortugas sanctuary. The reason for this conclusion is that there was an unusually large shrimp recruitment into the Tortugas shrimp fishery that preceded establishment of the sanctuary line. However, the line may have contributed to the continued high CPUE and high landings as well as preservation of the dominant modal group, thereby resulting in harvesting of large shrimp from October-December 1981.

Furthermore, questions arise as to how many fishermen refrained from fishing inside the sanctuary, as 33 violations were documented from May 1981 through March 1982 (Fuss).³ If considerable amounts of illegal fishing did occur, the catch results presented in this paper may be biased in terms of measures of CPUE. Thus the full benefits of the sanctuary would not be realized.

QUESTION 3: What are the size ranges of shrimp inside and outside the sanctuary area during the study period? (This answer is based on information from Roberts (MS)).

³Fuss, Charles; DOC, NOAA, NMFS, Southeast Regional Office, St. Petersburg, FL; personal communication.

Research cruises were conducted from September 1981 through February 1981. Stations were placed both inside and outside the sanctuary line (Fig 11), with the objective to determine whether the line should or could be moved $\pm 10\%$ and still protect juvenile pink shrimp from fishing. Although sampling was not conducted throughout the entire fishing grounds, our stations adequately reflect the shrimp population in the vicinity of the sanctuary line. The answer to this question is based on the shrimp sampling stations and is discussed in detail by Roberts (MS).

The average monthly relative abundance of shrimp from the survey station data for the entire study area varied throughout the study period from a low of 8.8 lbs⁴/30-min tow for one net in October to a high of 23.5 lbs in January. However, the CPUE inside the sanctuary area was always higher than outside the area. Inside the sanctuary, shrimp catch rates ranged from over 30 lbs/hr in January to a low of 11 lbs/hr in October, whereas outside the area, catch rates ranged from 6.4 lbs/hr in October to a high of 15.9 lbs/hr in January (Fig 12; Table 1). To specifically look at the differences in relative abundance between the inside and outside sanctuary areas, we have constructed Table 2 listing the number of stations in which a minimum commercial catch of ≥ 8 lbs/30-min tow⁵ for one net and the maximum

⁴Catches and catch rates of the research cruises are given in heads-on weight.

⁵A catch rate of 8 lbs heads on/30-min tow for one net is equivalent to approximately 322 lbs heads-off shrimp per 8 hours fishing with four nets and is defined as "minimum commercial catch".

number of pounds caught in a given month were recorded. This table clearly indicates that the waters inside the sanctuary in the "boot" area (west of the sanctuary line, running north-south) are prolific. Also, the waters inside the sanctuary are significantly more productive than the areas outside the sanctuary. Good catches were experienced throughout the Tortugas grounds both inside and outside the sanctuary only in January.

With regard to size, Roberts (MS) found that shrimp averaging 70-count or smaller, heads off, occurred both inside and outside the sanctuary line in all months except December. Likewise, shrimp that averaged larger than 70-count were found inside and outside the sanctuary in all six months of the study period. These data clearly indicate that the sanctuary line is not a knife-edge division which separated small and large shrimp during the 6-mo study period.

To further substantiate this statement, Roberts examined the percentage size distribution of shrimp smaller than the 70-count found inside and outside the sanctuary line from September 1981 to February 1982 (Table 4; Figs 13 and 14). It is clearly evident that 50% or more of the shrimp found inside the sanctuary in all months except December were smaller than 70-count and that outside the line much larger shrimp were found, although 34% or more of the population outside the sanctuary were considered to be small in all months except December.

During this study, proportions of shrimp smaller than 70-count on the Tortugas grounds ranged from a low of 26% in December to a high of 62% in January. Inside the sanctuary, the percentage of shrimp smaller than 70-count ranged from a low of 28% in December to a high of 68% in September, whereas the percentage of small shrimp was always less out-

side the sanctuary except in January and February. In December, very few less-than-70-count shrimp were found on the grounds. In January, over 68% of the shrimp outside the line were smaller than 70-count, whereas inside the line only 62% were that size.

One important question is what proportion of the small size pink shrimp (smaller than 70-count) in the area sampled was inside the sanctuary line. Table 5 and Fig 15 provide this information on a monthly basis and it is evident that the sanctuary line does, in fact, protect small size shrimp during all months, as a predominant proportion of small shrimp in the population in the area sampled is found inside the sanctuary from September through February.

Further, it is also evident that some portion of the shrimp population is inside the sanctuary and shrimp are larger than 70-count. This percentage varies by month throughout the 6-mo period and ranges from a low of 23% in September to a high of 50% in December (Table 5). It appears that in December, over 50% of the shrimp larger than 70-count were inside the sanctuary. Conversely, in December only 19% of the shrimp smaller than 70-count were inside the line. The biomass of shrimp smaller than 70-count was lowest in October and December and almost five times greater in January (Fig 14).

Therefore, we conclude that the sanctuary line, although it does not protect all of the small shrimp, does protect a high percentage of the shrimp in the Tortugas area. Florida Bay has been identified as the major nursery area for juvenile pink shrimp that are recruited to the Tortugas fishery (Costello et al. MS). It should be recognized, however, that the deeper waters of the Tortugas fishery were not adequately sampled, nor were the very shallow areas where extensive loggerhead sponges are located. Conceivably,

larger shrimp could be found in deeper waters and small juvenile shrimp found in the loggerhead sponge areas. Therefore, the data presented here only represent that portion of the study area that was sampled for the 6-mo period of time. However, we feel it is representative of the Tortugas fishery and as such, is an adequate sample.

QUESTION 4: What is the effectiveness of the sanctuary line in protecting small shrimp from fishing compared with alternative positions of the sanctuary line?

The survey data reported by Roberts (MS) indicated that 63% or more of the total number of shrimp smaller than 70-count/lb were found inside the sanctuary but also 56% or more of all shrimp larger than 70-count were found inside the sanctuary line (Table 6; Figs 15 and 16). The reason for this is that the highest biomass of pink shrimp was always concentrated inside the sanctuary area and that outside the restricted area, the shrimp stock was at least at a 50% lower level of abundance in all months except perhaps October (Table 1).

The relative abundance of shrimp on the Tortugas grounds varied throughout the 6-mo period (Fig 14). Highest biomass occurred in January, next highest in September, closely followed by November. Lowest biomass was encountered in October and December. The biomass of shrimp smaller than 103 mm TL for all stations reflected the general overall biomass and indicated that again September, November and January were the peak periods of small shrimp abundance. It appears there was a major recruitment to the grounds in January 1982.

Inside the sanctuary area, biomass again reflected the same peak time frames of abundance and these data indicated that the sanctuary does protect a large proportion of the

small recruiting shrimp (smaller than 70-count) in all months of the study. High concentrations of small shrimp (70-count) were found in September, November and January inside the sanctuary. It should be pointed out that a large proportion of the shrimp smaller than 70-count were also found outside the sanctuary in the month of January.

The MISS VIRGINIA, a chartered commercial shrimp vessel, was allowed to commercially drag two nights per month in any area they desired. In each of the six months, the MISS VIRGINIA elected to drag inside the sanctuary line. Their shrimp catches were large, ranging from a low of 6 lbs/30-min tow/net to a high of 34 lbs/30-min tow/net (Roberts, MS). In reviewing the specific catches per tow, 6 of the 70 commercial tows averaged smaller than 70-count shrimp for the six months of this study. Further, there were only 27 of 70 stations in which more than 50% of the catch was smaller than 70-count shrimp. The count size of the catch by the MISS VIRGINIA varied from 48 to 101, heads off.

This information provides a great deal of insight into the mixture of both small and large shrimp inside the sanctuary area. It also provides a clear indication that high catch rates can be expected inside the sanctuary, probably because of the restricted fishing. Outside the sanctuary, fishing in all months appears to be relatively poor except for January; therefore, the deliberate fishing by the MISS VIRGINIA inside the sanctuary was a result of knowledge based on sampling as well as knowledge of the fishery in that the catch rates were considerably greater inside the sanctuary, which was protected from all commercial fishing during the study period.

The data collected from the survey studies and the commercial tows made by the MISS VIRGINIA clearly indicate the major portion of the shrimp biomass was located inside the

sanctuary and that shrimp smaller than 70-count were predominantly found in this area, along with larger shrimp. The sanctuary could effectively protect small shrimp from September through February. However, few small shrimp were found on the grounds in December and therefore, at least in this month, the fishery was prevented from catching 70-count or larger shrimp inside the sanctuary when few small shrimp were present.

Alternative Positions for the Sanctuary Line

The Gulf of Mexico Fishery Management Council and the Management Advisory Panel have suggested several alternate positions for the sanctuary line. Obviously there are numerous alternative positions for this line; however, we have selected five options based on the GMFMC's recommendations. These options are as follows:

1. Extend the vertical shrimp line to Snipe Point and eliminate the western sanctuary line, called the "boot".
2. Move the horizontal line farther to the south some 3-4 nautical miles.
3. Move the horizontal line farther to the north 3-4 nautical miles.
4. Leave the line as is.
5. Seasonal closure.

Option 1: If the sanctuary line were drawn vertically to Snape Point, it would close only the eastern portion of the present sanctuary zone to commercial fishing. In reviewing the basic information, most of the shrimp from stations in this eastern area were consistently small throughout the study period. Moreover, low catch rates were experienced east of the sanctuary line and this area obviously serves as a nursery. Costello et al. (MS) clearly indicated that Florida Bay serves as a nursery area for

juvenile pink shrimp. However, the preponderance of the shrimp are moving out of that area westward within the sanctuary. This option would permit fishing in the "boot" area, which has been identified as an area which has large concentrations of small pink shrimp as well as large pink shrimp. The concentration of shrimp is highest in this area as compared to all other areas on the Tortugas grounds. This option would likely considerably increase fishing intensity on small shrimp.

Option 2: Move the horizontal sanctuary line farther to the south approximately 3-4 miles. This would virtually eliminate all protection for the "boot" area because if the line was moved that degree, it would be almost on a parallel line to the reef areas where trawling is not possible.

Option 3: Move the horizontal line farther to the north 3-4 miles. This probably would protect a few more small shrimp, but it would also eliminate fishing on the large shrimp which are also found in this area and would considerably minimize the fishable bottom on the Tortugas grounds.

Option 4: Leave the line as is. This option has been thoroughly reviewed in the data presented in this report and reports by Roberts (MS) and Klima et al. (MS).

Option 5: Seasonal closure. The data presented so far indicates that the months of September, November and January are key months in terms of protecting small pink shrimp on the Tortugas grounds. Very few small pink shrimp were found within the sanctuary area in December and little protection is afforded to the small shrimp population by the sanctuary during this month. A flexible open season could be considered if an adequate monitoring program could be established to determine when few small shrimp are inside the sanctuary. At such times, the sanctuary could be open

to fishing either for a fixed period of time or until the monitoring program determined that small shrimp were abundant in the sanctuary.

Recommendations

Option 4 or 5 appears to be the most realistic recommendation at this time. However, because 1981 was very different from all other years in the fishery, we recommend that no action be taken at this time but that, after reviewing the data at a later date when a full year's data is available, serious consideration be given to selecting months when the sanctuary area could be open to fishing if it poses no threat to protecting small juvenile shrimp on the grounds.

LITERATURE CITED

- Berry, R. J. 1967. Dynamics of the Tortugas (Florida) pink shrimp population. Ph.D. dissertation, University Microfilms, Ann Arbor, MI. 177 pp.
- Caillouet, C. W. and D. B. Koi. 1981. Trends in ex-vessel value and size composition of reported annual catches of pink shrimp from the Tortugas fishery, 1960-1978. Gulf Research Rep. 7(1):71-78.
- Costello, T. J. (MS). A historical review of regulations relating to the Florida Tortugas pink shrimp fishery.
- Costello, T. J., D. M. Allen and H. Hudson. (MS). Distribution, seasonal abundance and ecology of juvenile northern pink shrimp, Penaeus duorarum, in the Florida Bay area.
- Costello, T. J. and D. M. Allen. 1966. Migrations and geographic distribution of pink shrimp, Penaeus duorarum, of the Tortugas and Sanibel grounds, Florida. U.S. Fish Wildl. Serv., Fish. Bull. 65:449-459.
- Costello, T. J. and D. M. Allen. 1968. Mortality rates in populations of pink shrimp, Penaeus duorarum, on the Sanibel and Tortugas grounds, Florida. U.S. Fish. Wildl. Serv., Fish. Bull. 66:491-502.
- Ingle, R. M., B. Eldred, H. Jones and R. F. Hutton. 1959. Preliminary analysis of Tortugas shrimp sampling data 1957-1958. Florida St. Bd. Conserv., Tech. Ser. 32, 45 pp.

Iversen, E. S., A. E. Jones and C. P. Idyll. 1960. Size distribution of pink shrimp, Penaeus duorarum, and fleet concentrations on the Tortugas fishing grounds. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. No. 357, 62 pp.

Kutkuhn, J. H. 1966. Dynamics of a penaeid shrimp population and management implications. U.S. Fish Wildl. Serv., Fish. Bull. 65:313-338.

Lindner, M. J. 1965. What we know about shrimp size and the Tortugas fishery. Proc. Gulf Carib. Fish. Inst., 18th Ann. Sess.; pp.18-26.

Parrack, M. 1980. Some aspects of biological and monetary harvest optimization in the Tortugas pink shrimp fishery. Rep. of the Galveston Laboratory Fishery Data Analysis Division; 24 p.

APPENDIX A

Klima, Edward F., Geoffrey A. Matthews and Frank Patella.
MS. A synopsis of the Tortugas pink shrimp fishery,
1960-1981, and the impact of the Tortugas sanctuary.

Roberts, Terrell W. MS. A preliminary analysis of pink
shrimp (Penaeus duorarum) size and abundance during the
Tortugas shrimp sanctuary study, September 1981-February
1982.

APPENDIX B

COST SUMMARY

Data collection and research directed to the Tortugas sanctuary closure study were carried out by the Southeast Fisheries Center using funds in its FY82 base budget and funds supplied by the Gulf of Mexico Fishery Management Council. The following summary identifies the amounts and uses of the funds spent.

<u>Item</u>		<u>Total Cost</u>
1. Collection of resource survey data: Sept 1981-Feb 1982		
	Labor: \$74.2K	
	Other costs: <u>88.8K</u>	\$163.K
2. Analysis of catch and effort data:		
	Labor: \$10.6K	
	Other costs: <u>4.2K</u>	\$ 14.8K
3. Collection and management of catch and effort data (TIMS) (May-Dec):		
	Labor: \$64.1K	
	Other costs: <u>38.4K</u>	\$102.5K
4. Preparation of reports:		
	Labor: \$ 1.7K	
	Other costs: <u>0.5K</u>	\$ 2.2K
5. Total costs:		
	GMFMC: \$163.3K	
	SEFC: <u>119.5K</u>	\$282.8K

LIST OF FIGURES

- Figure 1. Location of 1957 controlled area in relationship to the southern tip of peninsular Florida and the Keys.
- Figure 2. Controlled area showing location of sampling stations used by the State of Florida in their 1957-1958 study of shrimp sizes (Ingle et al.; 1959).
- Figure 3. Pink shrimp nursery areas and controlled area of the Tortugas fishing grounds as enacted by the 1961 Florida legislature.
- Figure 4. Chart of Tortugas shrimp grounds with stone crab boundary and Tortugas closed fishing area.
- Figure 5. Annual shrimp landings in millions of pounds from statistical subareas 1, 2 and 3, 1960-1981 (solid line is average landings; broken line is one standard deviation).
- Figure 6. Average monthly pink shrimp landings in millions of pounds, 1960-1979, from statistical subareas 1, 2 and 3 ±one standard deviation.
- Figure 7. Monthly pink shrimp landings in millions of pounds in 1981 from statistical subareas 1, 2 and 3.
- Figure 8. Fishing effort in thousands of days fished in statistical subareas 1, 2 and 3 by year from 1960-1979 and 1981 (solid line is average effort and broken line is one standard deviation).

- Figure 9. Catch per unit effort from 1960-1979 and 1981 in statistical subareas 1, 2 and 3 (solid line is average, broken line is one standard deviation).
- Figure 10. Catch versus fishing effort in 1960-1979 and 1981 from statistical subareas 1, 2 and 3.
- Figure 11. Map of the Tortugas Shrimp Sanctuary showing the location of 24 stations designated for monthly sampling.
- Figure 12. Average CPUE by month from sampling stations inside and outside the sanctuary.
- Figure 13. Relative abundance in percent of pink shrimp ≤ 103 mm TL at sampling stations inside and outside the sanctuary by month.
- Figure 14. Relative abundance in number of pink shrimp by month.
- Figure 15. Percent of pink shrimp population ≤ 103 mm TL and > 103 mm TL occurring inside and outside the sanctuary by month.
- Figure 16. Percent of pink shrimp population ≤ 103 mm TL and > 103 mm TL occurring inside the sanctuary area.

LIST OF TABLES

Table 1. Mean CPUE (lb/30-min tow/1 net, heads on) of pink shrimp from stations inside and outside the Tortugas closure study. Calculations are based on 46 tows (2/station) from which length measurements were taken.

Table 2. Measure of relative abundance inside the Tortugas sanctuary in Area A (west of the vertical closure line) and Area B (east of the vertical closure line) and outside the sanctuary (column 1, the number of stations with 8 lb/30-min tow for 1 net over the total number of stations and column 2, the number in parentheses is the number of stations having the maximum catch per 30-min tow/net).

Table 3. Number of stations sampled for pink shrimp according to average size group (≤ 103 mm TL and ≥ 103 mm TL) and location (inside or outside the sanctuary area).

Table 4. Percentage of pink shrimp ≤ 103 mm TL and ≥ 103 mm TL occurring at sampling stations inside and outside the sanctuary and combined by month.

Table 5. The relative abundance in percent of pink shrimp found inside and outside the sanctuary based on the total population of shrimp taken at all sampling stations combined (except for stations F1 and F2). The shrimp are divided according to total length ≤ 103 mm and ≥ 103 mm.

Table 6. Percent of the pink shrimp population ≤ 103 mm TL occurring inside the sanctuary, and percent of the population ≥ 103 mm TL occurring inside the sanctuary.

Table 1. Mean CPUE (lb/30-min tow/1 net, heads on) of pink shrimp from stations inside and outside the Tortugas closure study area. Calculations are based on 46 tows (2/station) from which length measurements were taken.
 STD = Standard deviation.

<u>CRUISE</u>	<u>INSIDE</u>	<u>OUTSIDE</u>	<u>COMBINED</u>
September 1981			
CPUE	19.96	9.25	14.84
STD	15.52	4.95	12.88
October 1981			
CPUE	11.03	6.40	8.82
STD	8.96	5.65	7.67
November 1981			
CPUE	23.92	10.16	17.34
STD	20.96	6.26	11.36
December 1981			
CPUE	19.25	9.92*	14.68*
STD	8.60	6.69	9.26
January 1982			
CPUE	30.43	15.86	23.46
STD	15.51	9.17	14.79
February 1982			
CPUE	17.25	6.81	13.58
STD	9.75	4.52	8.90

*2 tows were missing.

Table 2. Measure of relative abundance inside the Tortugas sanctuary in Area A (west of the vertical closure line) and Area B (east of the vertical closure line) and outside the sanctuary (column 1, the number of stations with 8 lb/30-min tow for 1 net over the total number of stations and column 2, the number in parentheses is the number of stations having the maximum catch per 30-min tow/net).

Month	Inside sanctuary area				Outside sanctuary area	
	Area A		Area B		(1)	(2)
	(1)	(2)	(1)	(2)		
September	8/9	(2) 40 lbs	1/1	--	5/11	--
October	6/10	(2) 20 lbs	3/3	--	4/11	(1) 20 lbs
November	9/10	(6) 24 lbs	2/2	(2) 24 lbs	6/11	(1) 24 lbs
December	9/10	(3) 27 lbs	1/2	(1) 27 lbs	4/9	--
January	10/10	(9) 21 lbs	1/3	--	8/11	(4) 21 lbs
February	9/9	(2) 30 lbs	1/2	(1) 30 lbs	2/11	--

Column 1 gives the number of stations with ≥ 8 lb/30-min tow for one net (net before slash) and the total number of stations sampled (number after slash). Column 2 gives the number (in parentheses) of stations having a catch/30-min tow/net as large as or larger than the given value.

Table 3. Number of stations sampled for pink shrimp according to average size group (≤ 103 mm TL and > 103 mm TL) and location (inside or outside the sanctuary area).

Month	Average size ≤ 103 mm TL		Average size > 103 mm TL		Total No. Stations Sampled
	<u>Inside</u>	<u>Outside</u>	<u>Inside</u>	<u>Outside</u>	
September	X	X	X	X	21
October	X	X	X	X	23
November	X	X	X	X	23
December			X	X	21
January	X	X	X	X	23
February	X	X	X	X	23

Table 4. Percentage of pink shrimp ≤ 103 mm TL and ≥ 103 mm TL occurring at sampling stations inside and outside the sanctuary and combined by month.

<u>Month</u>	<u>Inside</u>		<u>Outside</u>		<u>Combined</u>	
	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
	<u>≤ 103</u>	<u>≥ 103</u>	<u>≤ 103</u>	<u>≥ 103</u>	<u>≤ 103</u>	<u>≥ 103</u>
September	68	32	37	63	59	41
October	50	50	34	66	44	56
November	51	49	45	55	48	52
December	28	72	23	77	26	74
January	62	38	68	32	64	36
February	55	45	56	44	55	45

Table 5. The relative abundance in percent of pink shrimp found inside and outside the sanctuary based on the total population of shrimp taken at all sampling stations combined (except for stations F1 and F2). The shrimp are divided according to total length $\lt 103$ mm and ≥ 103 mm.

<u>Month</u>	<u>Inside</u>		<u>Outside</u>		<u>Combined</u>	
	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
	$\lt 103$	≥ 103	$\lt 103$	≥ 103	$\lt 103$	≥ 103
September	48	23	11	18	59	41
October	33	33	12	23	44	56
November	36	37	12	15	48	52
December	19	50	7	24	26	74
January	41	25	23	11	64	36
February	40	33	15	12	55	45

Table 6. Percent of the pink shrimp population ≤ 103 mm TL occurring inside the sanctuary, and percent of the population ≥ 103 mm TL occurring inside the sanctuary.

<u>Month</u>	<u>Percent</u> <u>≤ 103 mm TL</u>	<u>Percent</u> <u>≥ 103 mm TL</u>
September	82	56
October	73	59
November	75	71
December	72	67
January	63	70
February	72	73

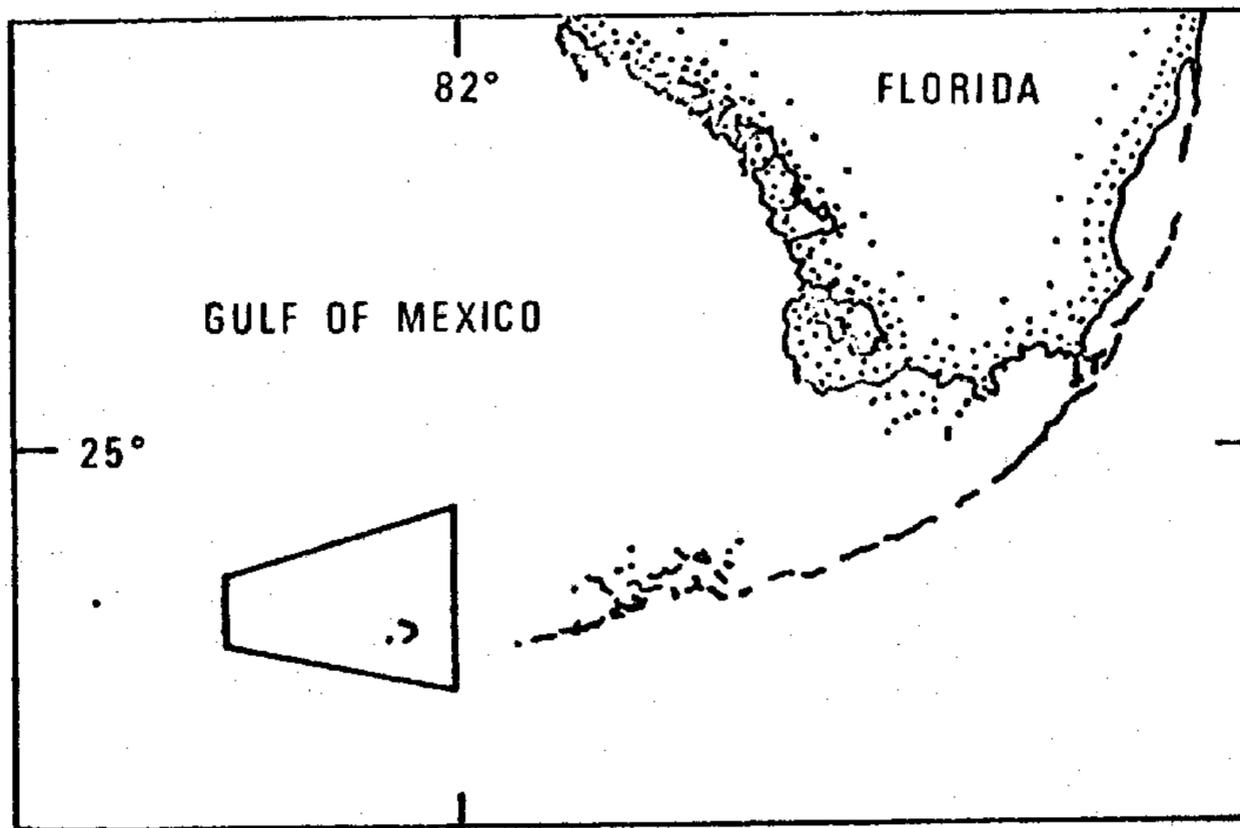


Figure 1. Location of 1957 controlled area in relationship to the southern tip of peninsular Florida and the Keys.

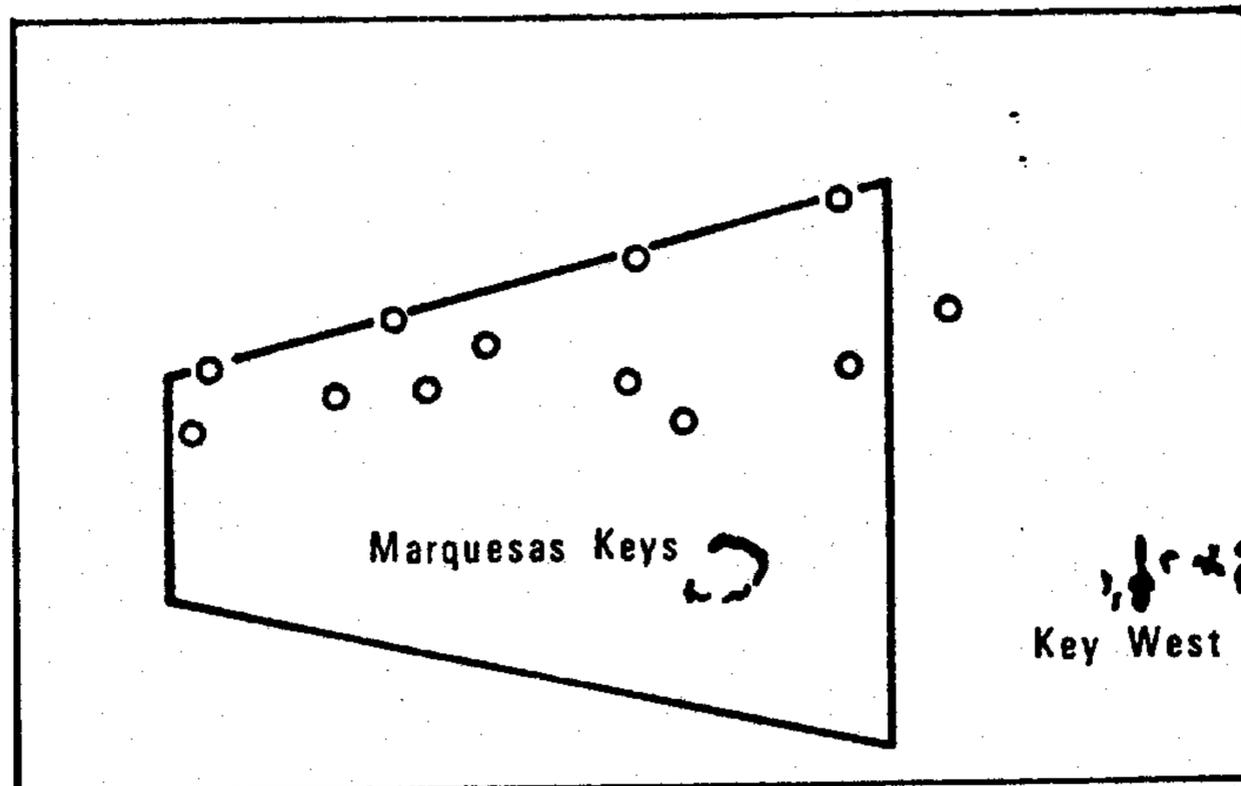


Figure 2. Controlled area showing location of sampling stations used by the State of Florida in their 1957-1958 study of shrimp sizes (Ingle et al.; 1959).

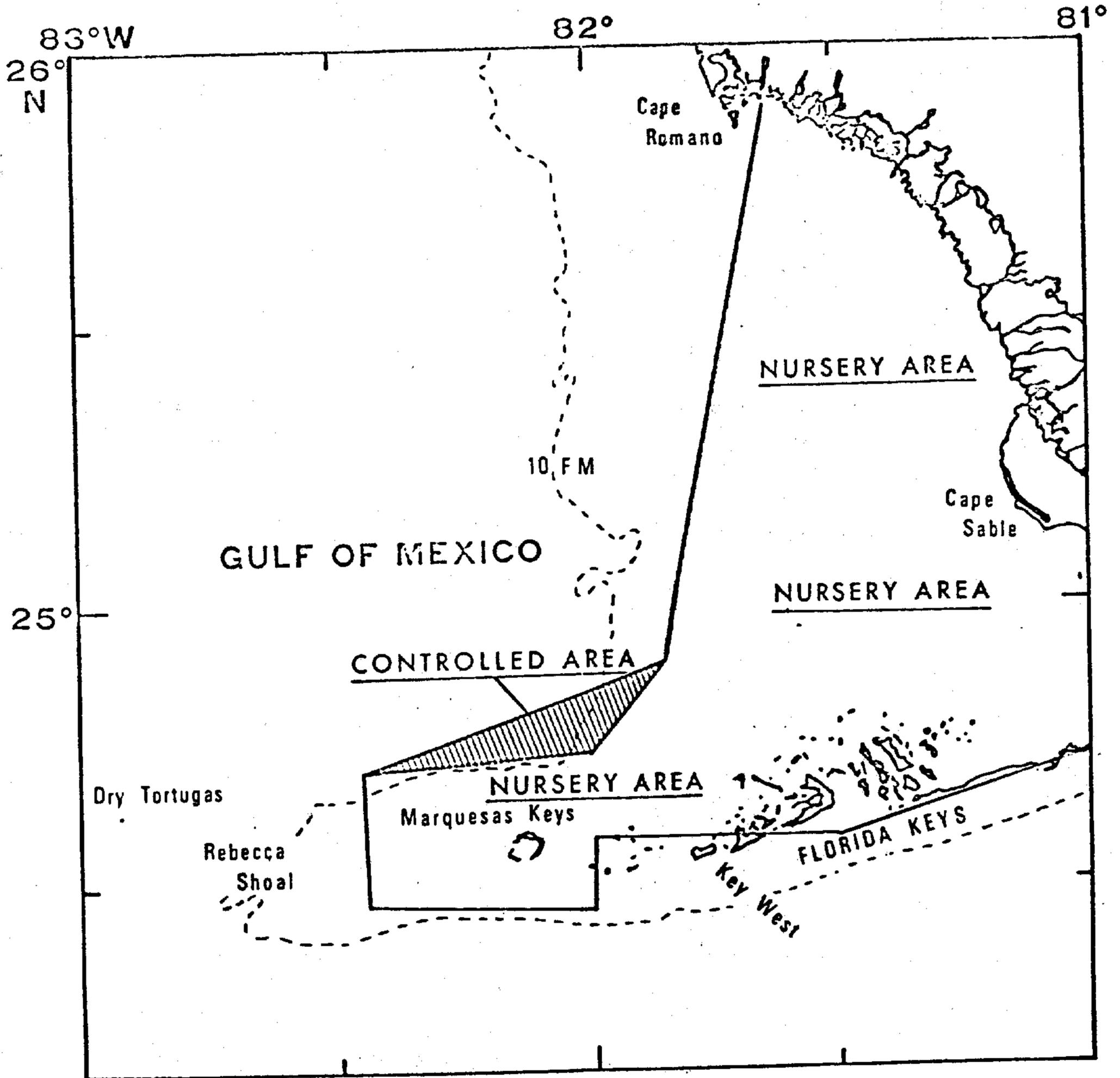


Figure 3. Pink shrimp nursery areas and controlled area of the Tortugas fishing grounds as enacted by the 1961 Florida legislature.

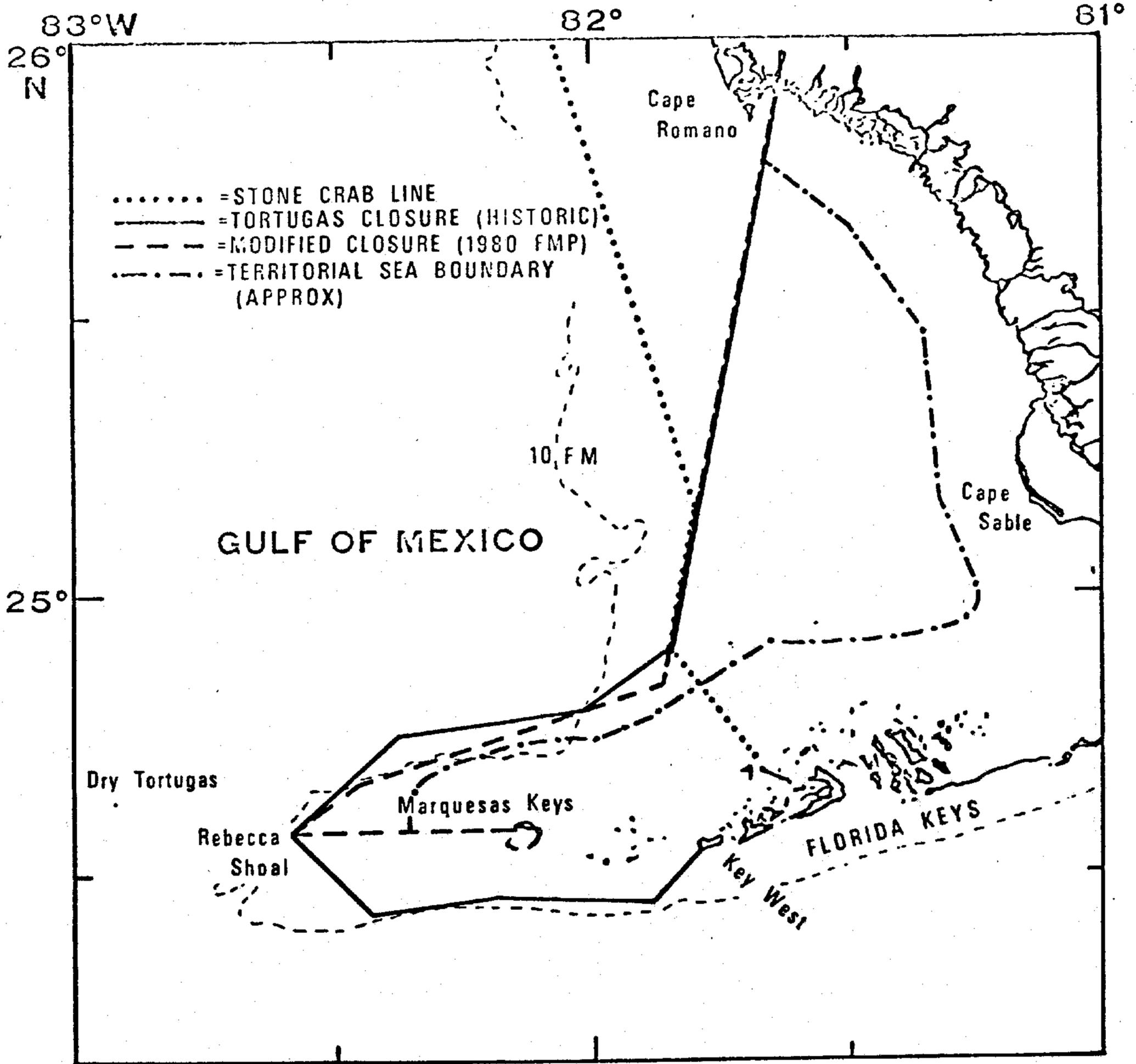


Figure 4. Chart of Tortugas shrimp grounds with stone crab boundary and Tortugas closed fishing area.

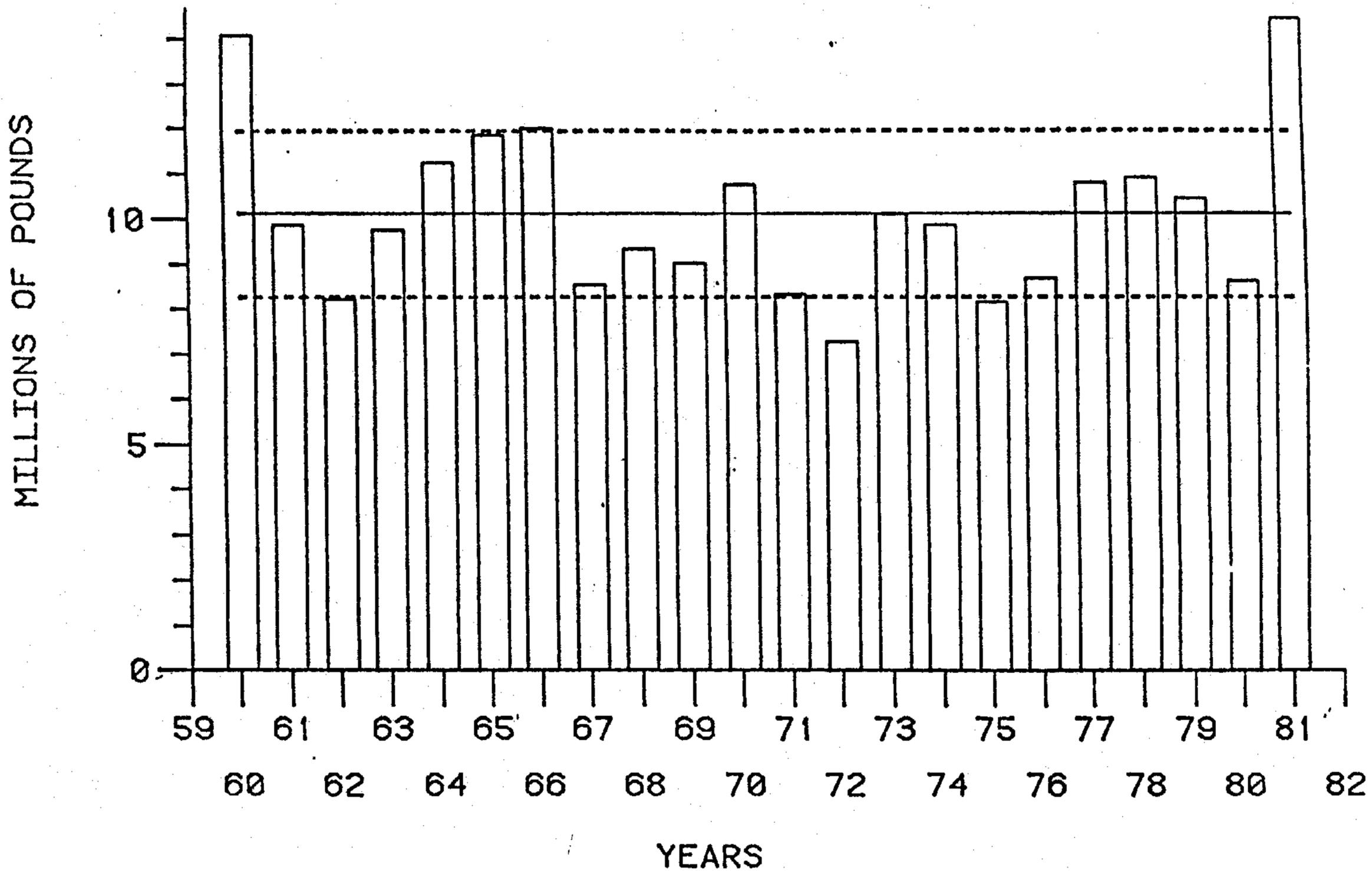


Figure 5. Annual shrimp landings in millions of pounds from statistical subareas 1, 2 and 3, 1960-1981 (solid line is average landings; broken line is one standard deviation).

MILLIONS OF POUNDS

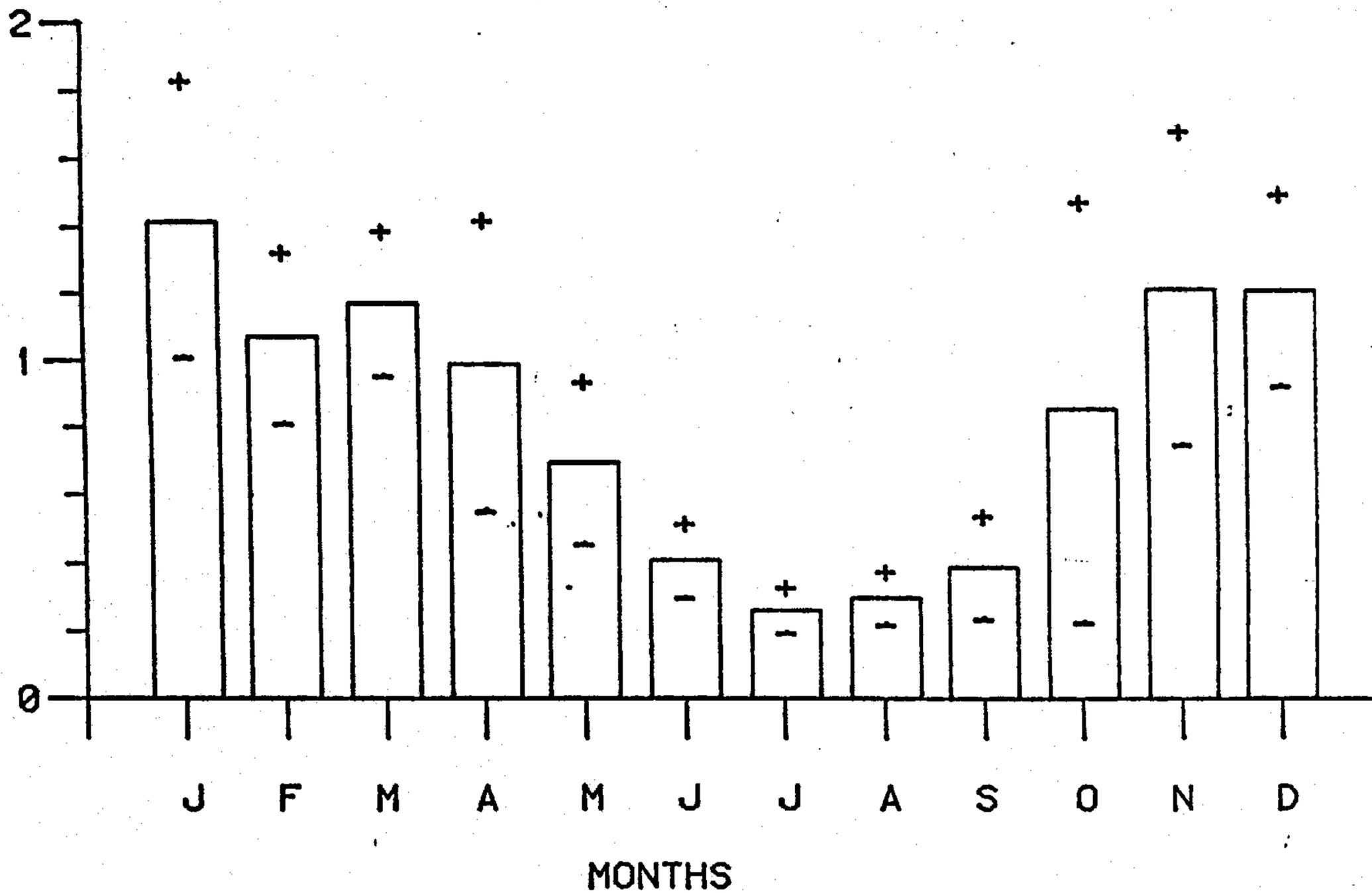


Figure 6. Average monthly pink shrimp landings in millions of pounds, 1960-1979, from statistical subareas 1, 2 and 3 ±one standard deviation.

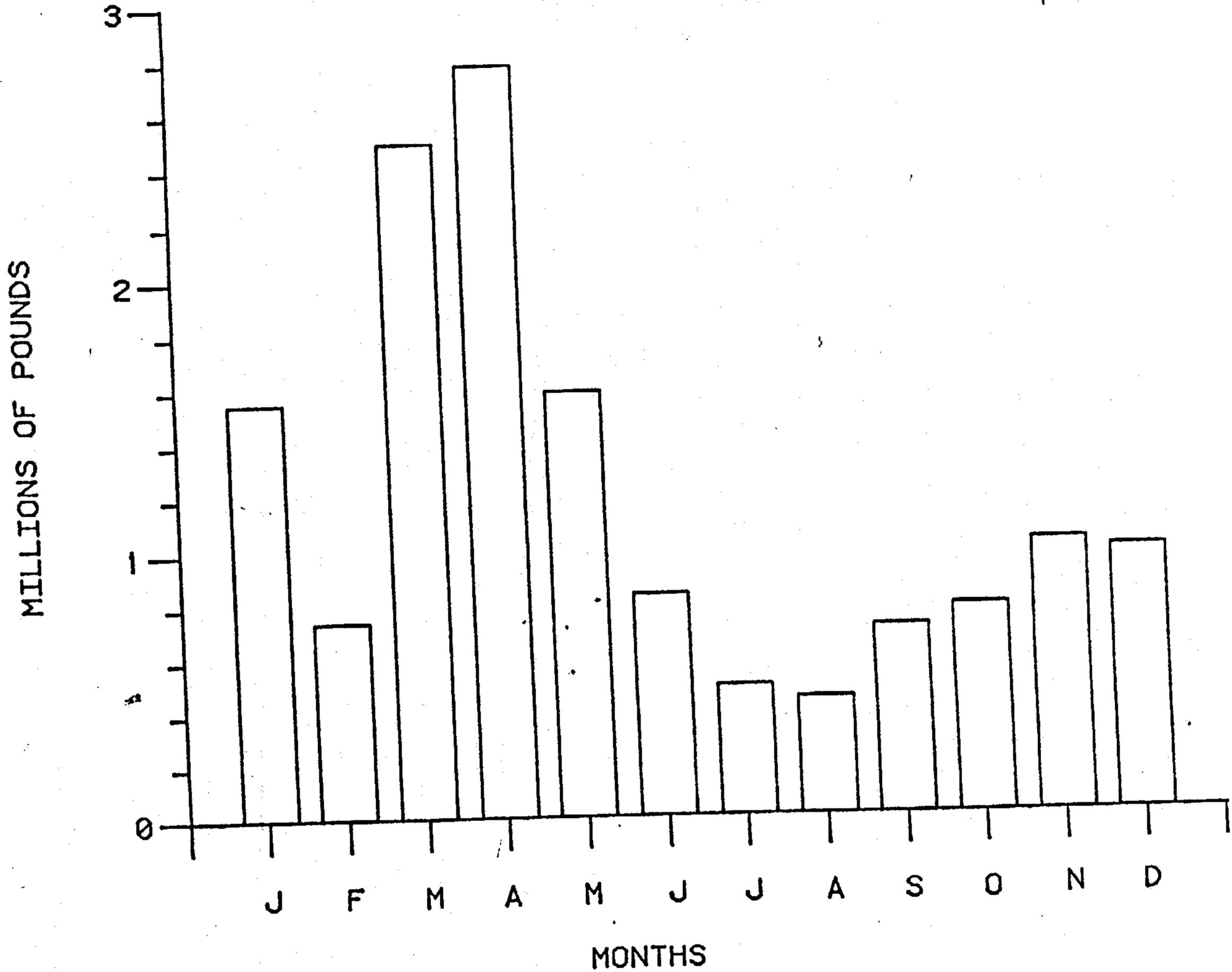


Figure 7. Monthly pink shrimp landings in millions of pounds in 1981 from statistical subareas 1, 2 and 3.

THOUSANDS OF DAYS FISHED

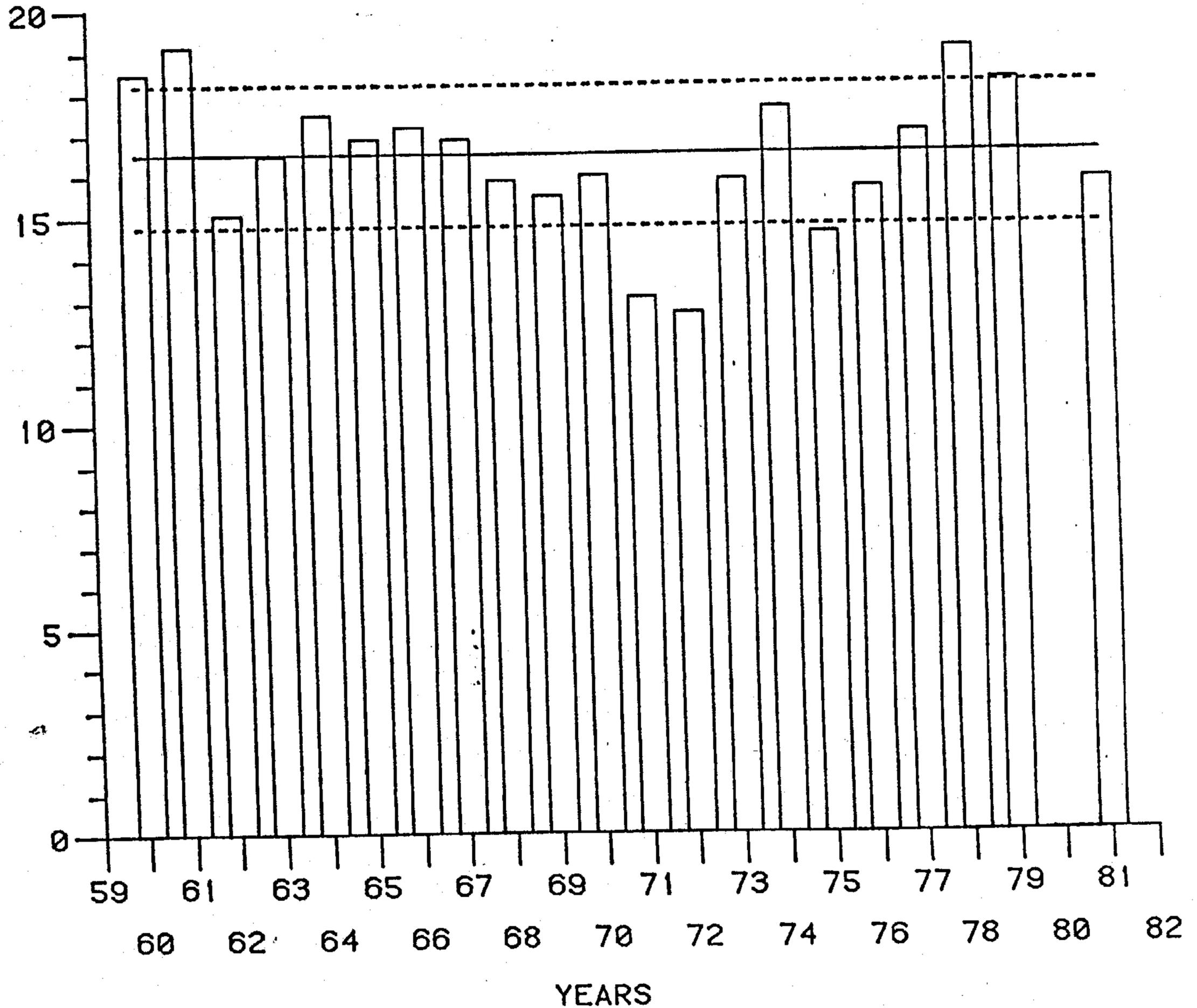


Figure 8. Fishing effort in thousands of days fished in statistical subareas 1, 2 and 3 by year from 1960-1979 and 1981 (solid line is average effort and broken line is one standard deviation).

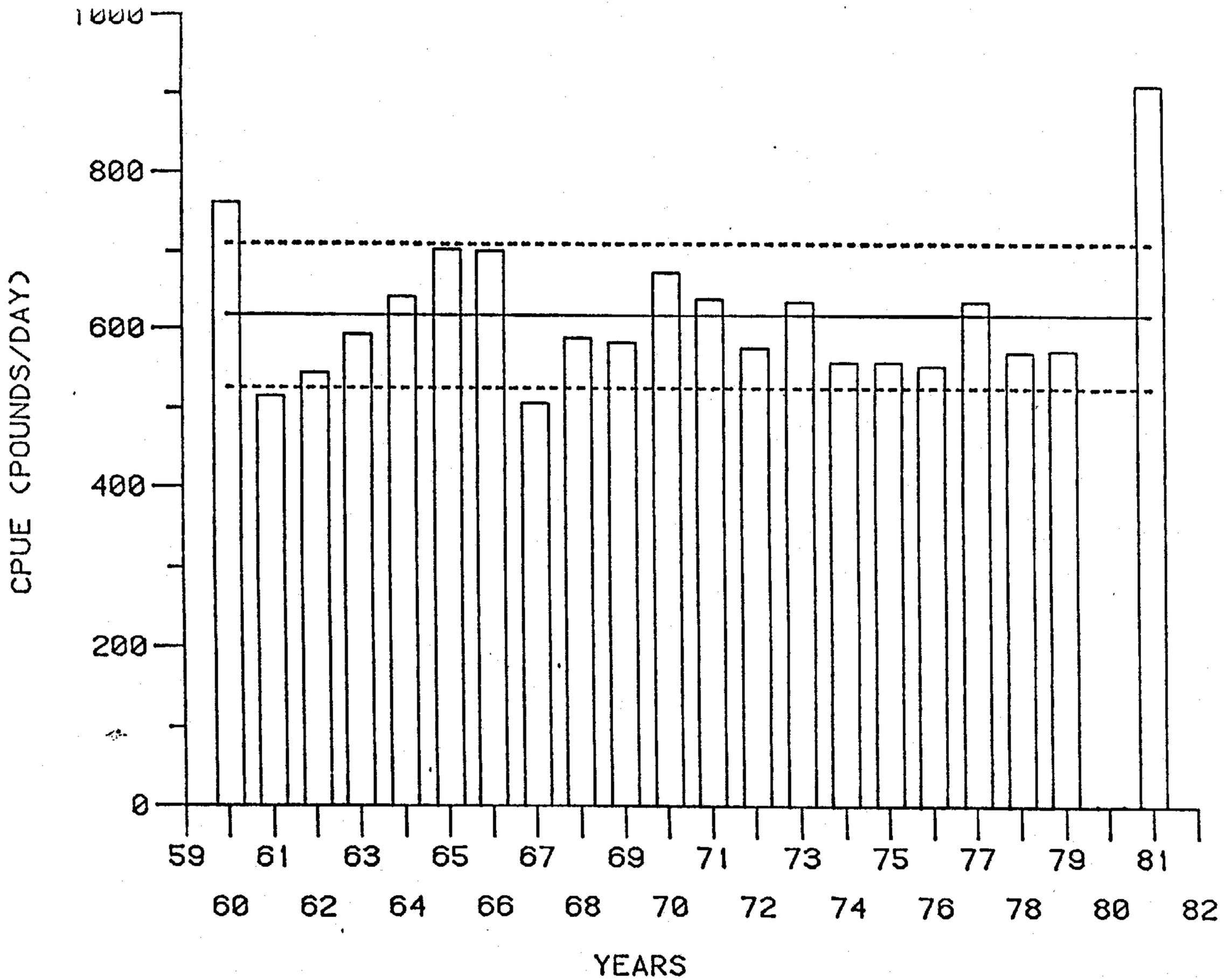


Figure 9. Catch per unit effort from 1960-1979 and 1981 in statistical subareas 1, 2 and 3 (solid line is average, broken line is one standard deviation).

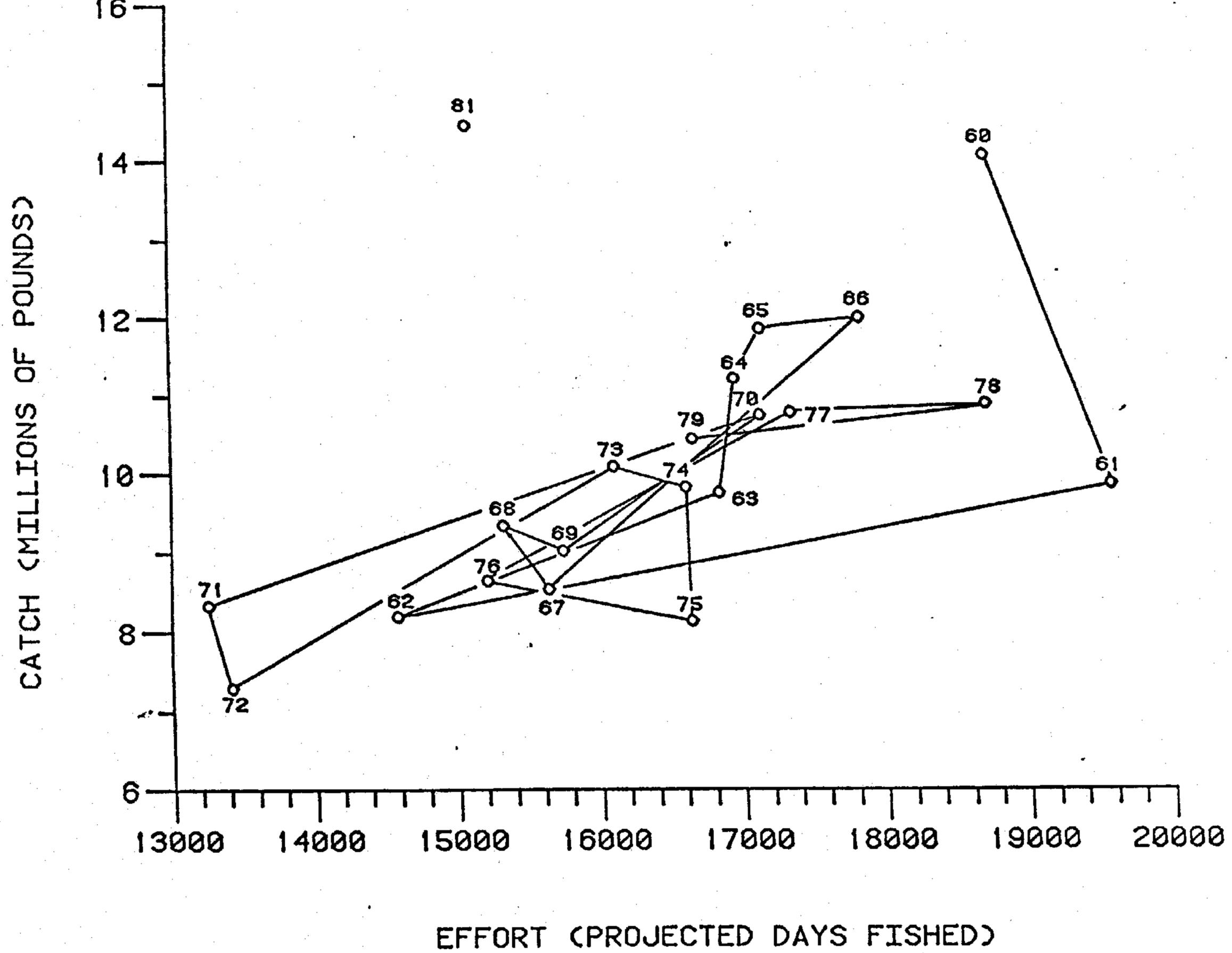


Figure 10. Catch versus fishing effort in 1960-1979 and 1981 from statistical subareas 1, 2 and 3.

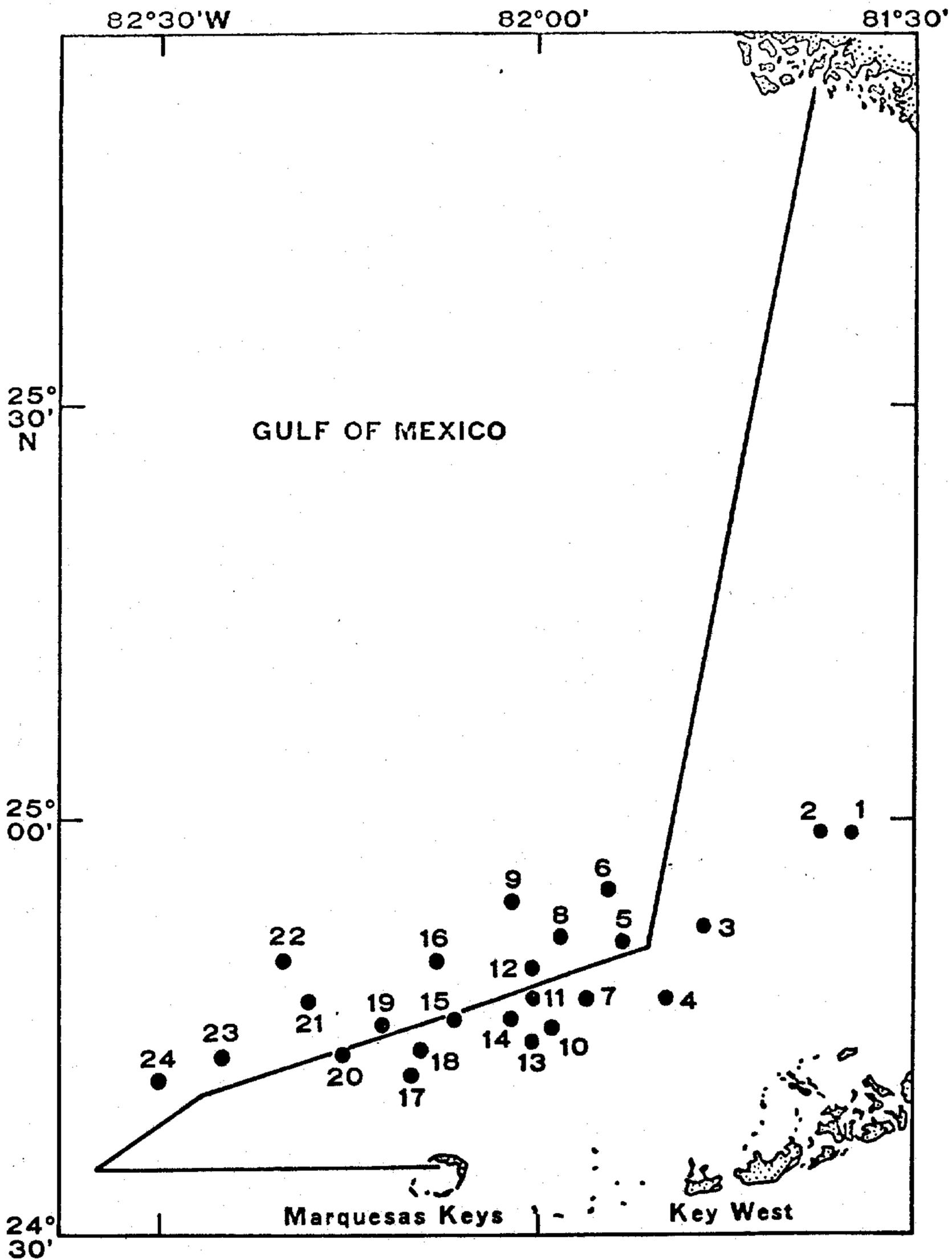


Figure 11. Map of the Tortugas Shrimp Sanctuary showing the location of 24 stations designated for monthly sampling.

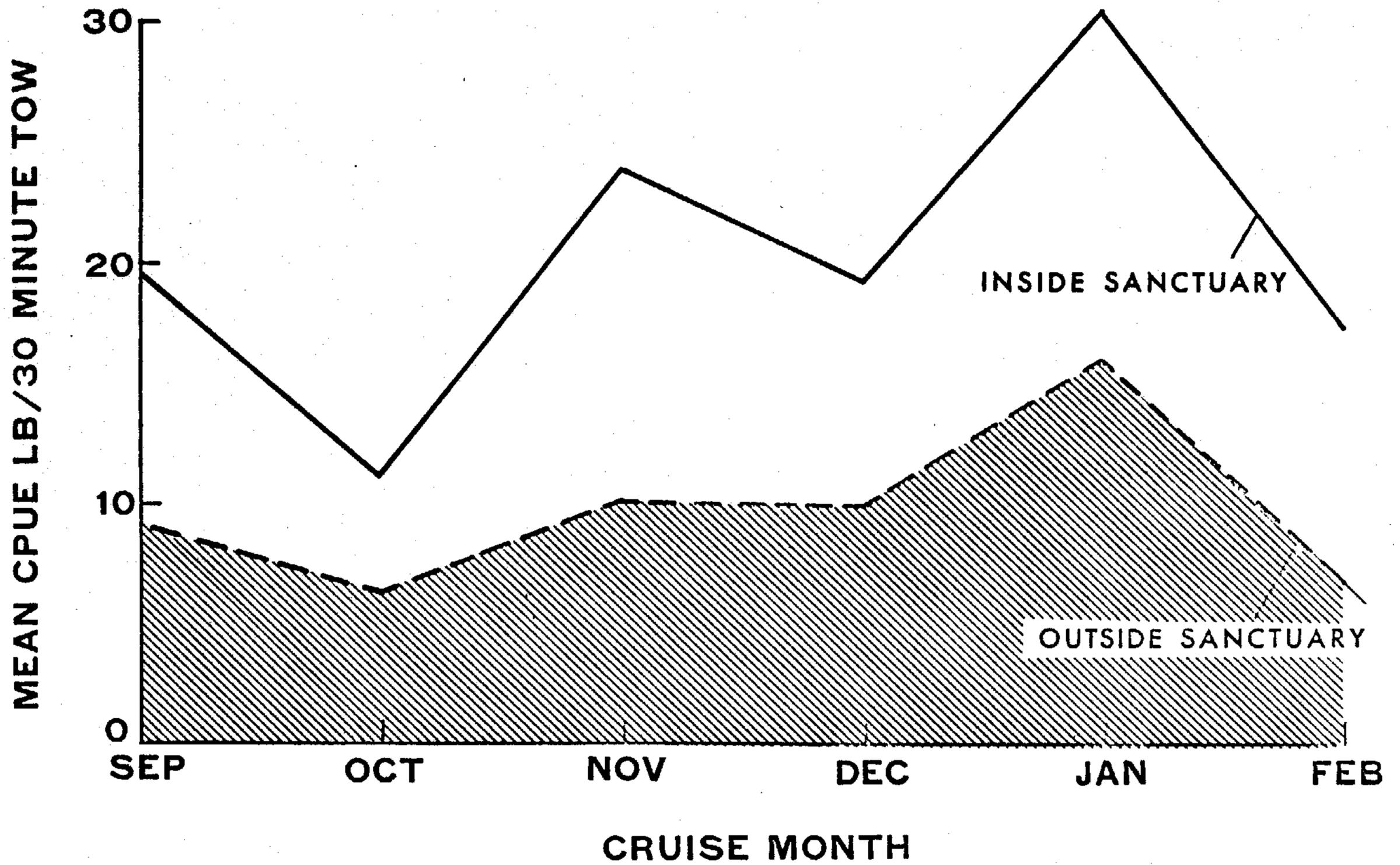


Figure 12. Average CPUE by month from sampling stations inside and outside the sanctuary.

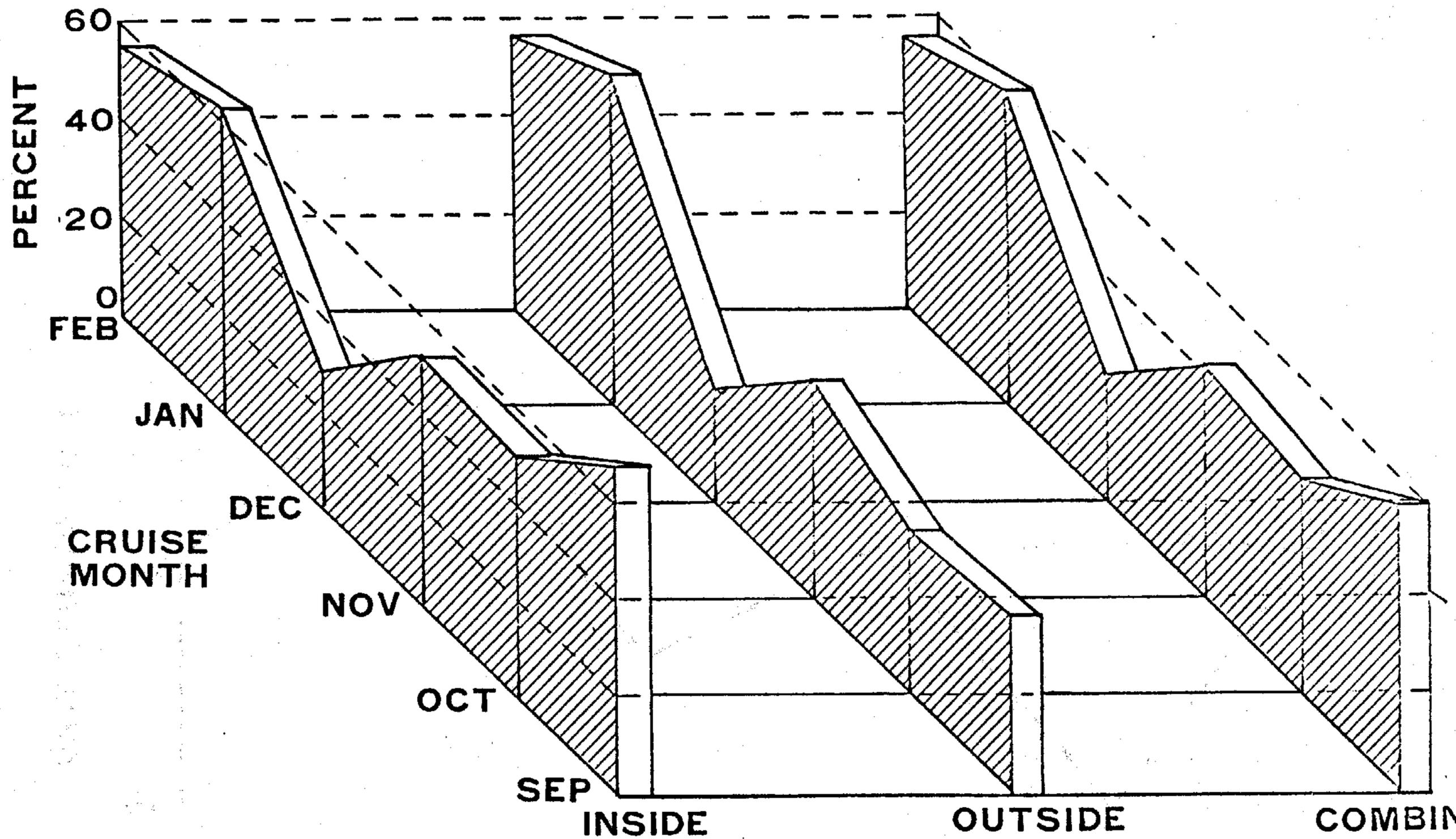


Figure 13. Relative abundance in percent of pink shrimp <103 mm TL at sampling stations inside and outside the sanctuary by month.

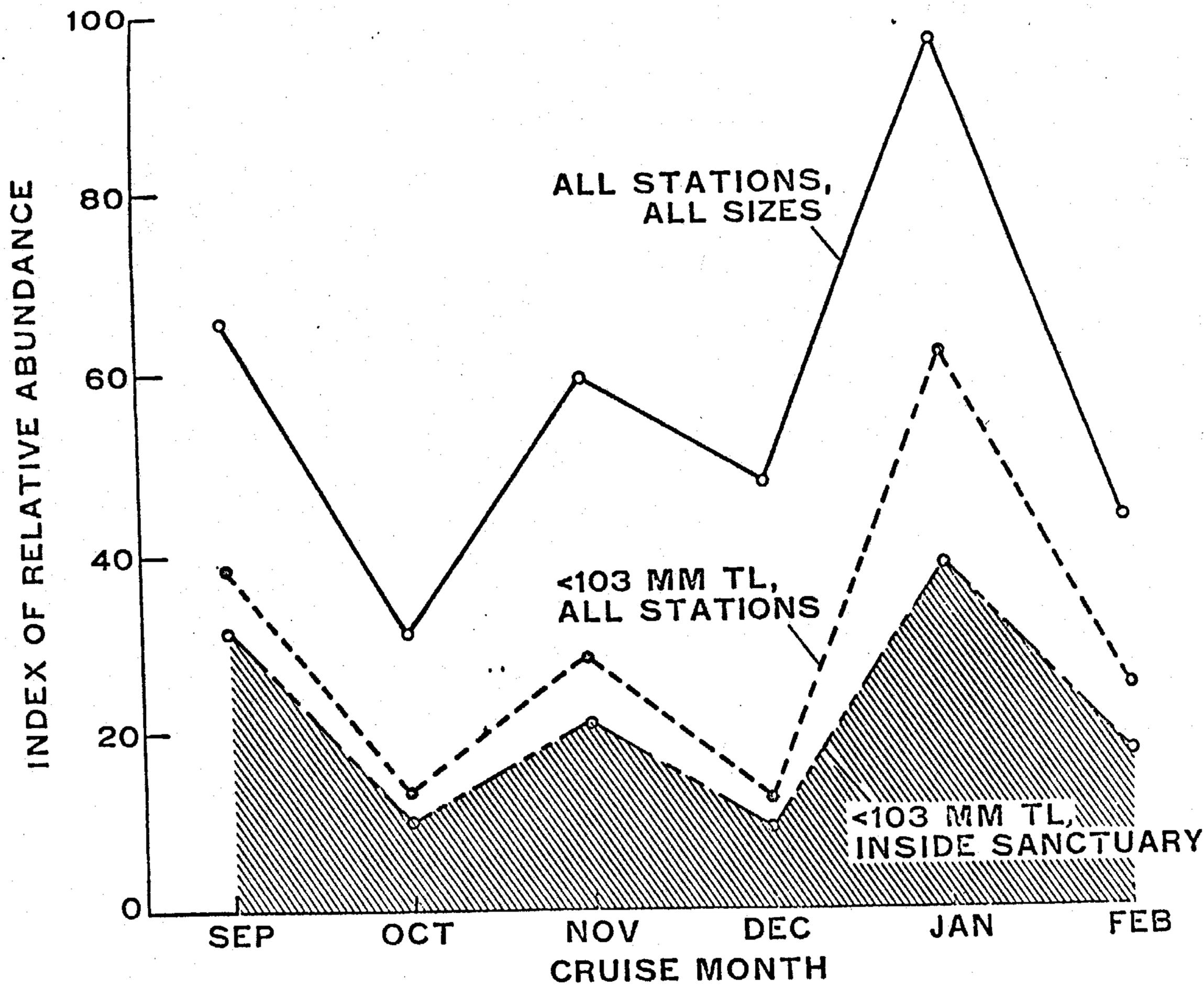


Figure 14. Relative abundance in number of pink shrimp by month.

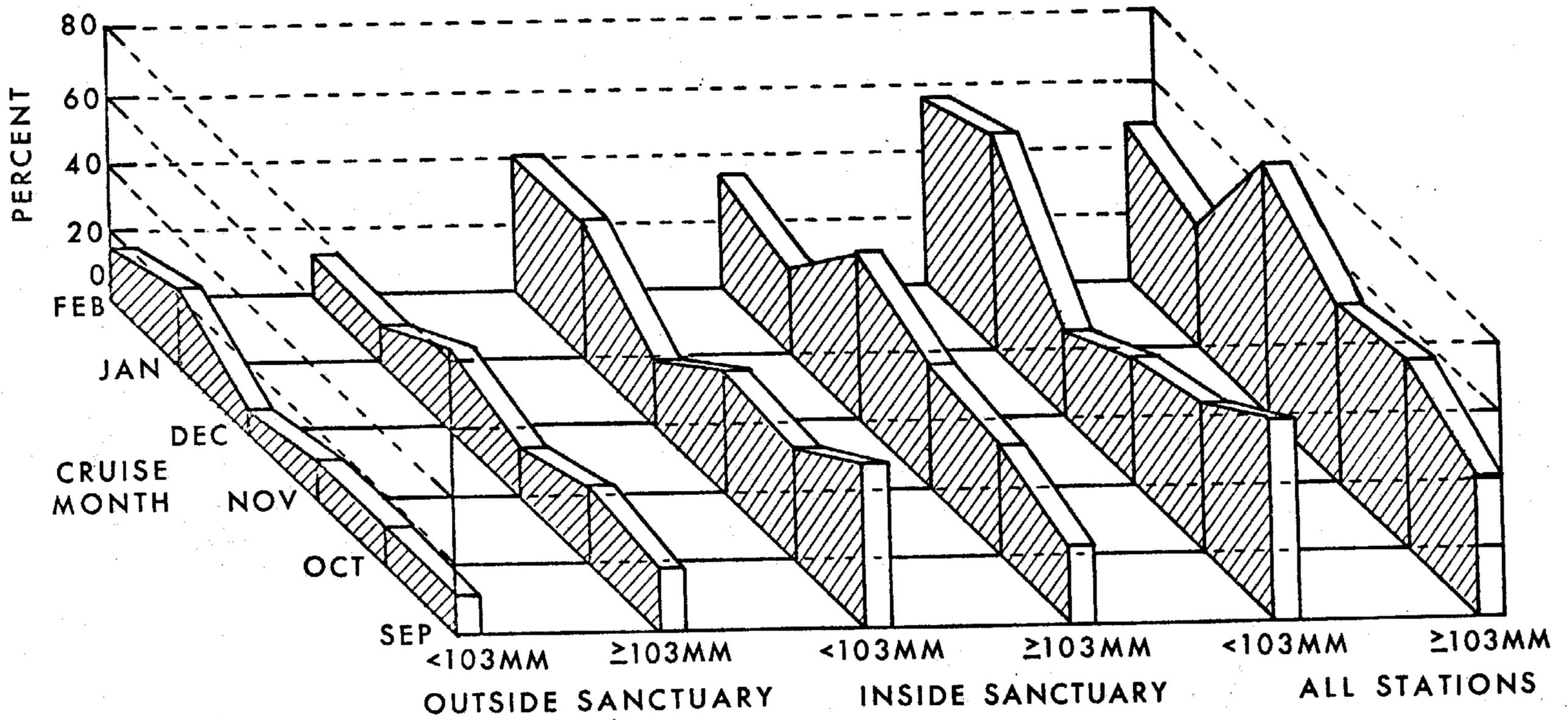


Figure 15. Percent of pink shrimp population <103 mm TL and ≥103 mm TL occurring inside and outside the sanctuary by month.

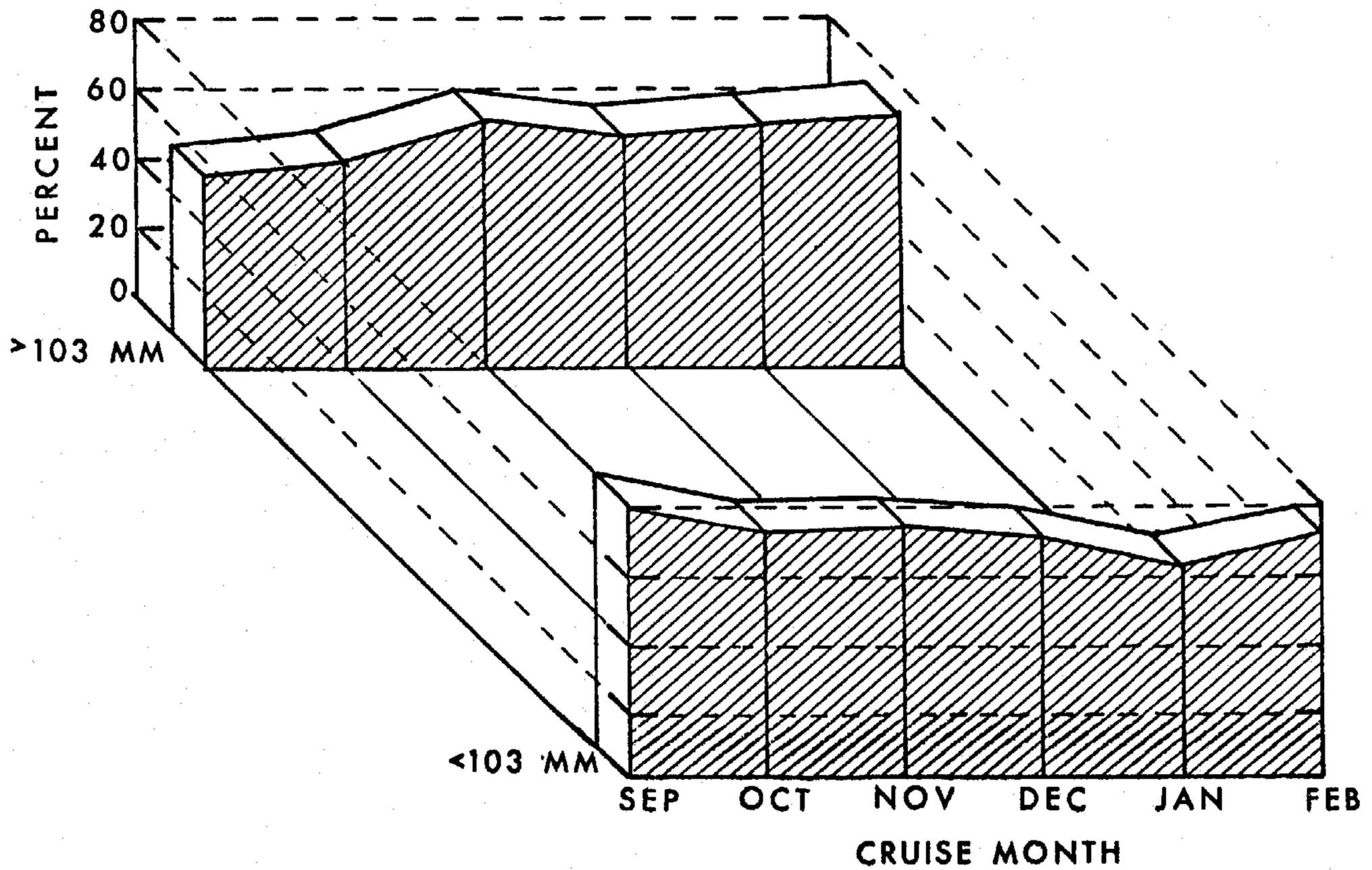


Figure 16. Percent of pink shrimp population <103 mm TL and >103 mm TL occurring inside the sanctuary area.