Impacts of the Combined Closures of the Texas Territorial Sea and FCZ on Brown Shrimp Yields

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This paper examines the effects of the combined closures of the Texas Territorial Sea and the FCZ off Texas on brown shrimp yields (in pounds). The Gulf-wide simulation model used in the evaluation of the FCZ-only closure has been reconstituted to project yields that would have been expected in 1981 and 1982 had both the Texas Territorial Sea and the FCZ been open. In addition, some more general yield per recruit results are presented. These general models allow an estimate of the maximum gain that could be attained via closure management techniques, and demonstrate the trade-offs between yields to inshore and offshore fisheries.

GULF-WIDE YIELDS, HAD BOTH THE FCZ AND TERRITORIAL SEA BEEN OPEN

The same simulation modelling techniques used in the FCZ-only analysis (Nichols 1984) was applied to the combined closure case. The virtual population analysis (VPA) described in Nichols (1984) was again used to obtain estimates of fishing mortality rates and recruitment under existing conditions. The practical difficulty becomes "what would fishing have been like had both the FCZ and Texas Territorial Sea been open?" I generated fishing mortality rates for the case of both areas open for 1981 and 1982 conditions by assuming that the 1981 and 1982 age-specific fishing mortality rate for the Texas offshore fishery (outside 5 fm) would be applied two months (and two ages) earlier with both the FCZ and Territorial Sea open. Fishing mortality rates for the Texas inshore/nearshore fishery (to 5 fm), and for fishing elsewhere in the Gulf were held constant. Winter (December-April) rates in all areas were also held unchanged. Fishing was simulated for the May-April period for 1981 and 1982 seasons, starting with recruitments estimated by the VPA.

Gulf-wide yields observed with both the Territorial Sea and FCZ closed exceed the yields projected for fishing with both areas open by 8.9 million pounds (9%) for the 1981 season, and by 4.2 million pounds (6%) for the 1982 season. Estimated changes in catch by market category are shown in Figures 1 and 2. Marked differences in (Gulf-wide) standing stock on the grounds during the current peak season were also projected: 36% lower in 1981 (1 August), 30% lower for 1982, if the closures had not existed.

GENERAL YIELD PER RECRUIT RESULTS

Results from some more generalized yield per recruit models are included here to illustrate the maximum potential for optimum size management to judge the existing closures against, and to evaluate the trade-offs between inshore and offshore yields. Parrack's (1981) estimates of growth and length-weight conversions, and Nichols's (1982) estimate of natural mortality rate (0.28 per month) are the basic inputs. Knife-edged recruitment at 45 mm tail length (about 220 tails/pound) is assumed. Calculations used a Ricker-type model (Ricker 1975) with two time steps per month through 18 months. Age-specific fishing mortality rates (F's) used as "current values" were averages of the 1981-1983 F's for peak season recruits (April-July cohorts) estimated by VPA (Nichols 1982). To illustrate maximum potential, a model with constant F for all ages was also used. The "current" fishing mortality rate under this simplification would be approximately 0.5 per month.

Yield per recruit is plotted against age at first capture and fishing mortality rate (constant with age case) in Figure 3. At the assumed current, Gulf-wide F of 0.5, a net gain 17% in yield (pounds) is expected with fishing delayed 1½ months after recruitment (at size of about 68 tails/pound). This is the maximum that could be expected at current fishing levels by changing from a completely unmanged fishery to one with an optimal closure policy.

Yield per recruit in dollars can be calculated by replacing the growth in weight with age by growth in dollar value. Yield per recruit models in dollars should not be considered formal economic analyses, because the dynamics of price changes with yield changes are not incorporated. The intent here is simply to provide some general guidance about gains in value to accompany the information about gain in pounds. Average prices by market size category for 1981-83 were used to establish a smooth curve relating shrimp size and price per pound (Figure 4), and from that a relationship value per individual for each age. All yields are gross yields (calculating net yields would require knowledge of the cost of harvest per pound by size class; these costs are not yet known). Yield per recruit in dollars is plotted against age at first capture and F in Figure 5. At F = 0.5, maximum ex-vessel yield in dollars could be attained by delaying harvest for three months after recruitment (at about 39 tails/pound). The dollar yield with this delay would be 94% greater than the yield if fishing began immediately at recruitment.

These yield per recruit isopleth diagrams can be extended to plot yield as a function of any pair of variables. In this case, these diagram will be used to evaluate the separate affects of the inshore fishery and the offshore fishery on offshore yields, and on total yields. Decompositon of the VPA-derived fishing mortality rates into inshore and offshore components revealed that almost all of the F for the first two months after recruitment is applied inshore or nearshore (about 71% strictly inshore; 83% inshore, plus offshore to 5 fm) and that almost all of the F after that is offshore (over 90% strictly offshore, about 75% outside 5 fm). Therefore, varying F independently on the two age segments (the first two months and all following months) will model independent variations in the "inshore" and "offshore" fisheries.

Offshore yields in pounds (Figure 6) respond very rapidly to changes in inshore fishing mortality. Halving inshore fishing (keeping offshore fishing constant) will increase offshore poundage yields by 56% (for a given recruitment). Doubling inshore fishing will reduce offshore yields 59%. Offshore yields less responsive to offshore fishing mortality rate. Doubling offshore fishing (holding inshore fishing constant) would increase offshore yield (pounds) by 17%; halving offshore fishing would decrease offshore yields by 28%.

Total yield per recruit (pounds) from the fishery does not change very rapidly with changes in either inshore or offshore fishing (Figure 7). Doubling inshore fishing mortality (holding offshore fishing constant) would reduce total yields 7%; halving the inshore fishery would increase total yield per recruit by 4%. Doubling offshore fishing (inshore constant) would increase total yield per recruit 8%; halving would lead to a 12% decrease.

Offshore yield per recruit in dollars (Figure 8) is very responsive to changes in inshore fishing, but not to changes in offshore fishing. Doubling inshore fishing mortality would decrease offshore dollar yields per recruit by 59%; halving inshore fishing would increase dollar yield per recruit by 58%. Doubling offshore fishing mortality (with inshore fishing constant) would increase offshore dollar yields by 6%; halving would produce a 23% decrease.

Total yield per recruit in dollars (inshore and offshore) would decrease 31% with a doubling of inshore fishing from current levels (Figure 9). Halving inshore fishing would increase total yield per recruit 25%. Doubling offshore fishing mortality would increase total dollar yield per recruit by 4%. Halving offshore fishing would reduce total dollar yield per recruit by 15%.

DISCUSSION

The simulations of Gulfwide yields, had the Territorial Sea and FCZ been open, show that the combined closures are performing exactly as intended. Potential yields in the 68+ market size category are bypassed in favor of higher yields larger more valuable shrimp, predominately in the 31-40 and larger market categories. The percentage gains of 6-9% are understandable, measured against the maximum attainable gain of 17% estimated by the general yield per recruit model: only the stock off Texas is protected until July, fishing is permitted inside 4 fm, and there are already delayed openings in place in the other Gulf States.

The benefit in pounds in 1981 was much greater than the benefit in 1982. This should be expected: recruitment in 1981 was considerably better than in 1982. Closure management is aimed at improving yield per recruit, and is not expected to impact recruitment. However, the percentage change in yield was also lower in 1982 than in 1981, which is a consequence of something other than simply lower recruitment. There are a number of factors that could influence this drop in percentage, but the most conspicious difference between 1981 and 1982 was the magnitude of the inshore/nearshore fishery. Klima et al. (1984) have pointed out the that 1981 and 1982 inshore landings were very similar, despite evidence of considerably lower recruitment in 1982.

VPA-derived estimates of inshore/nearshore fishing mortality (to 5 fm) show a sharp increase between 1981 and 1982 (Figure 10). The long-term trend in Figure 10 is also striking. The magnitude of the trend (about a 3-fold increase since the early 1960's) explains why doublings and halvings of the fishery were considered in the previous section: the inshore fishery has changed that mu:h, and may yet increase further.

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Figure 1. Estimated change in Gulf-wide brown shrimp yield due to combined Texas Territorial Sea and FCZ closures, May 1981 - April 1982.

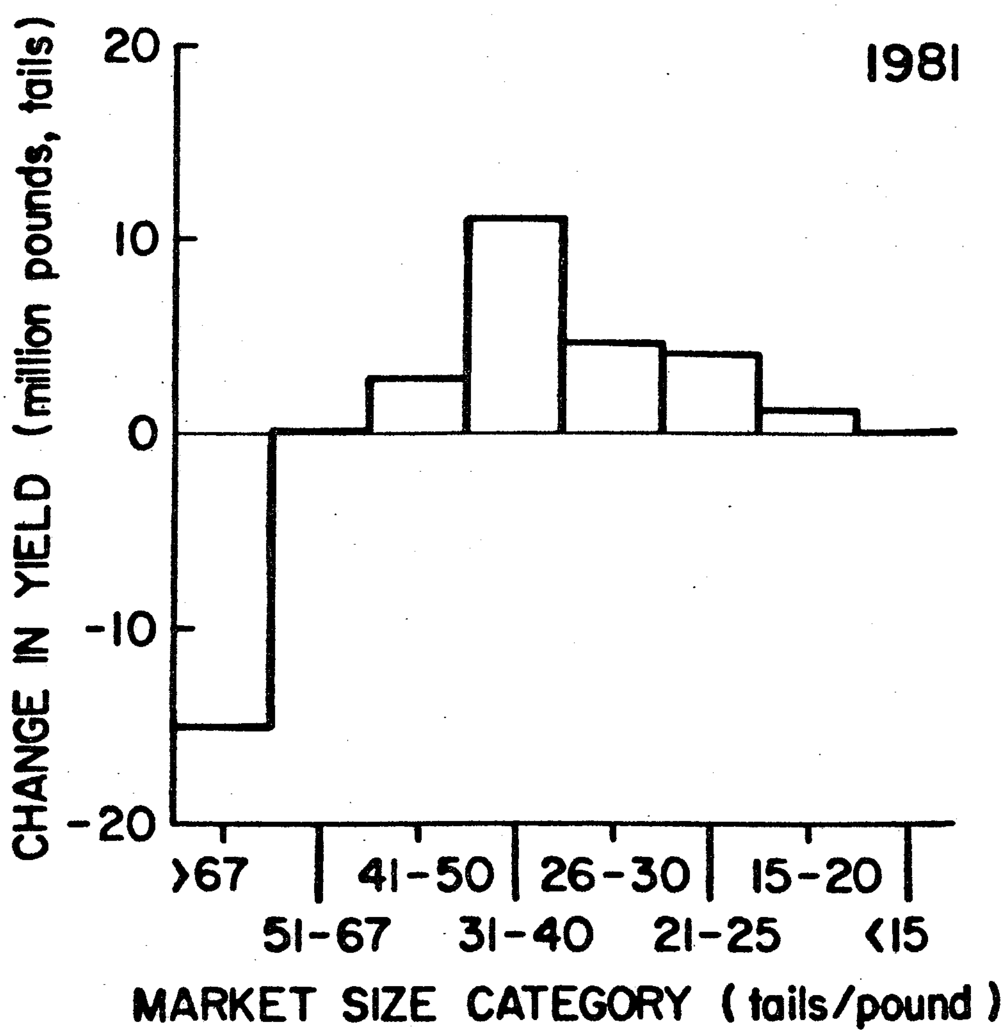

Figure 2. Estimated change in Gulf-wide brown shrimp yield due to combined Texas Territorial Sea and FCZ closures, May 1982 - April 1983.

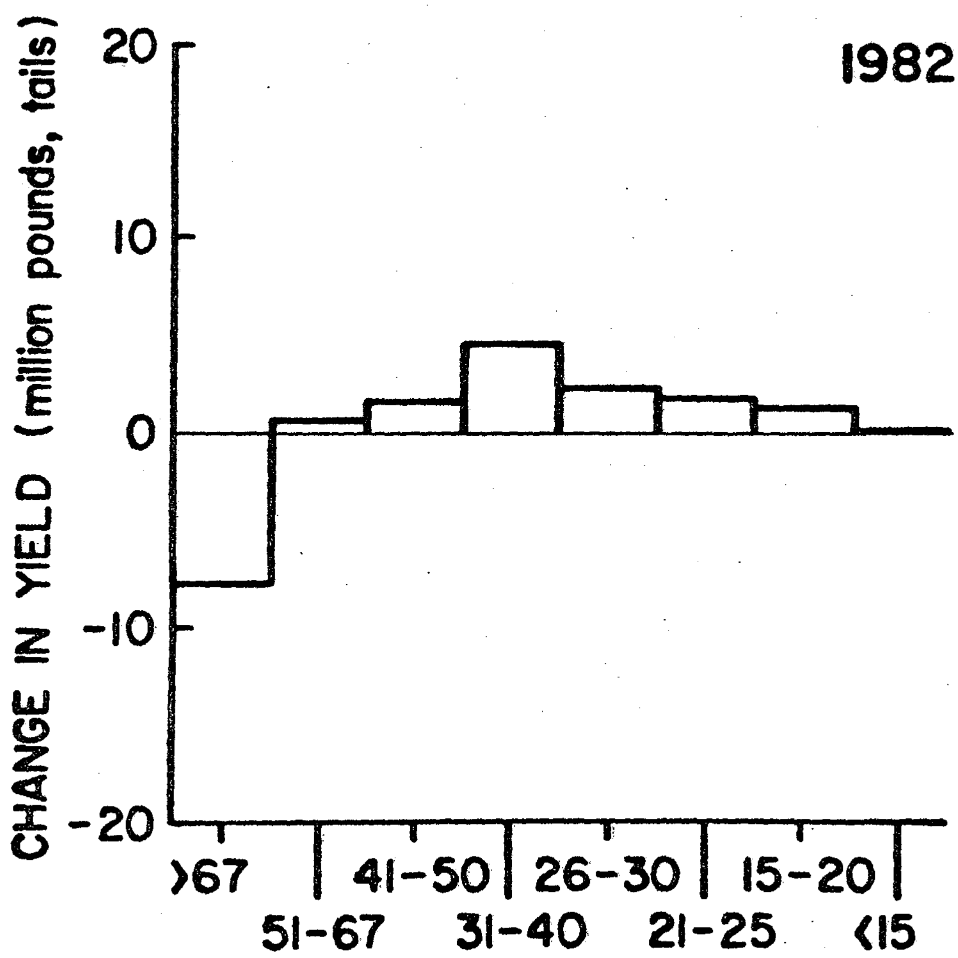

Figure 3. Yield per recruit isopleth diagram, relating that yield per recruit in grams (contours) to age at first capture and fishing mortality rate.

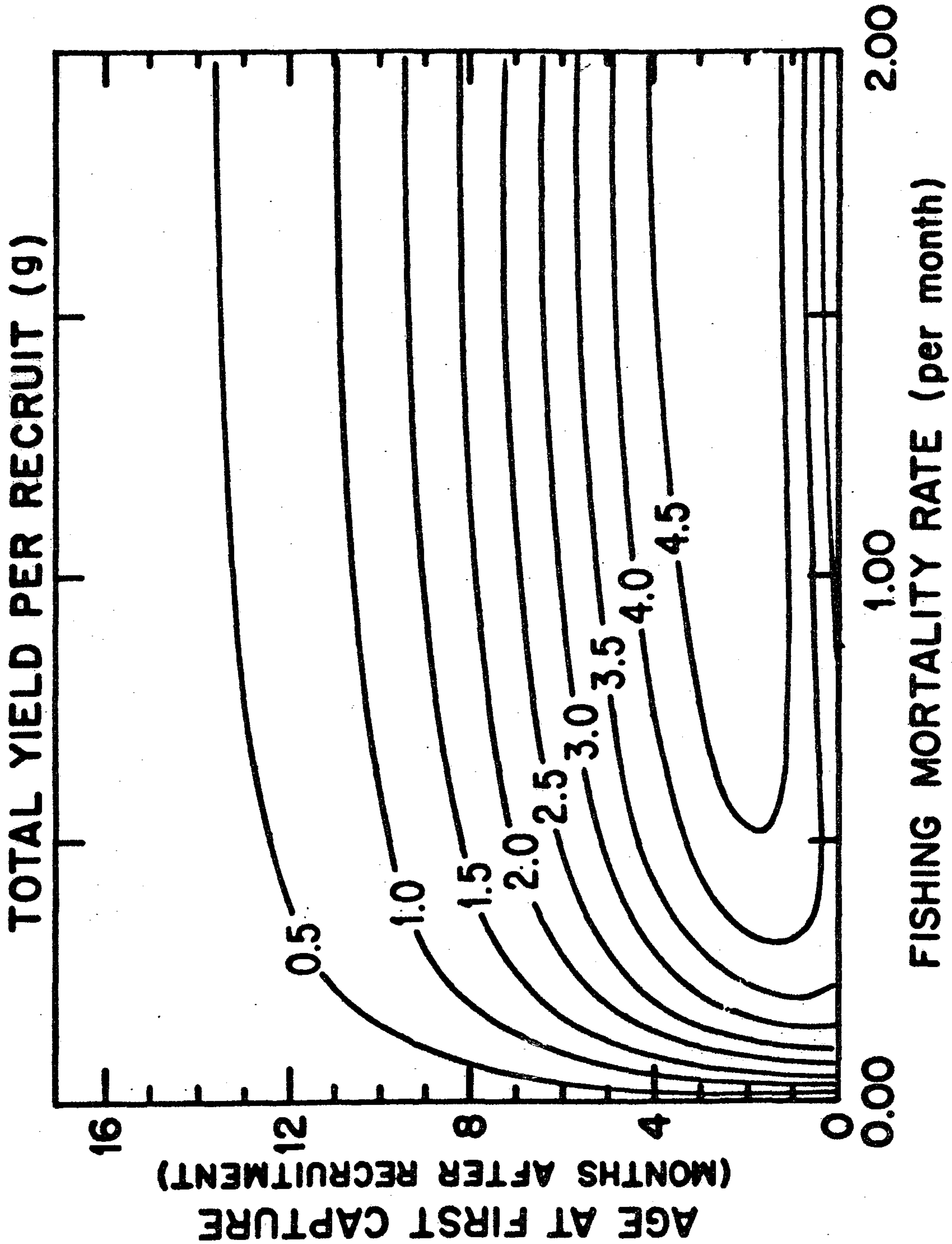

Figure 4. Smoothed relationship between ex-vessel price per pound and tail weight for brown shrimp. Smoothed curve is a quadratic function fit to the midpoints of the nominal size intervals for market size categories (tails/pound). Horizontal lines depict the ranges of the most standard categories. Price data are averages for 1981-1983.

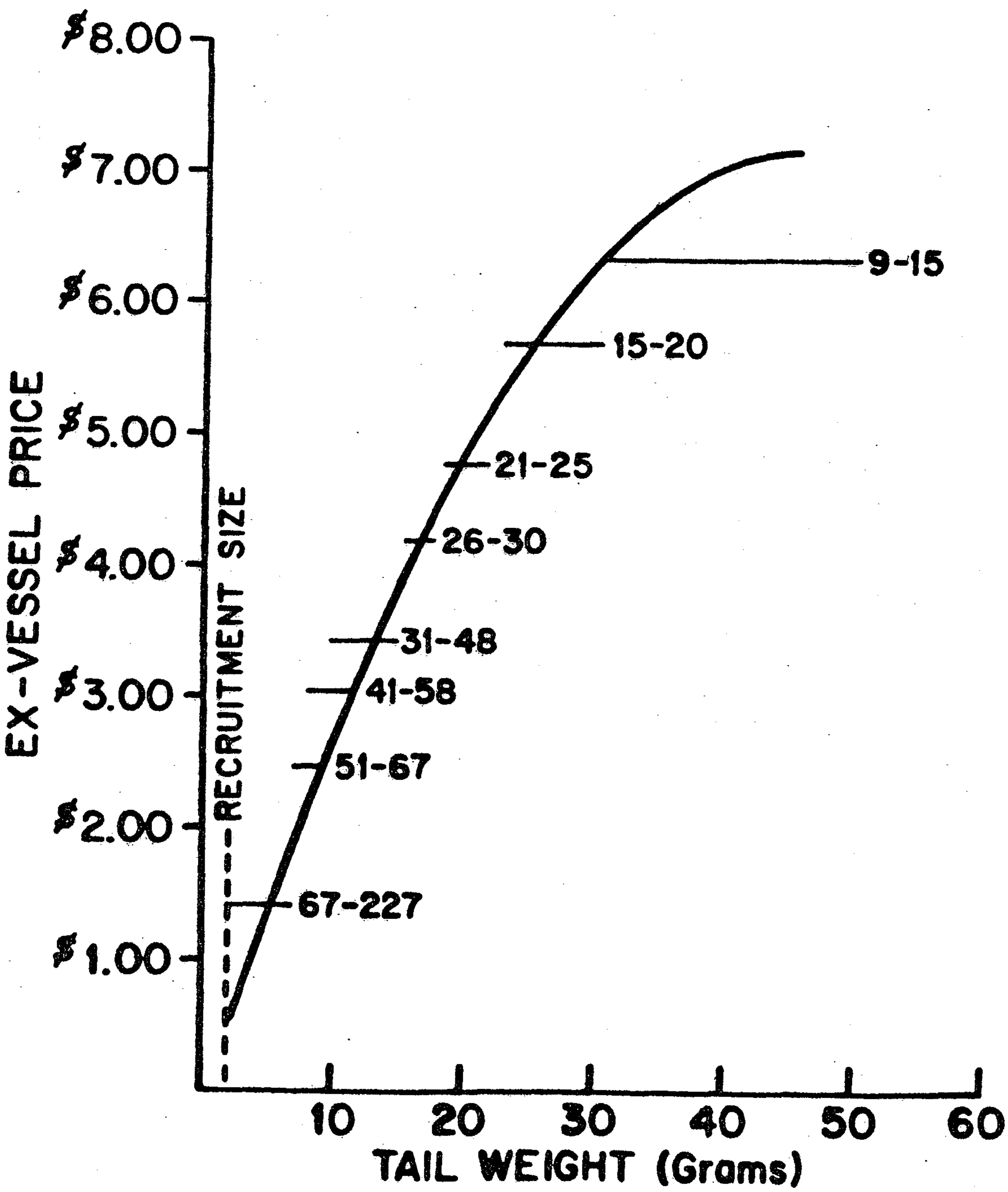

Figure 5. Yield per recruit isopleth diagram, relating total yield per recruit in dollars (ex-vessel gross) to age at first capture and fishing mortality rate.

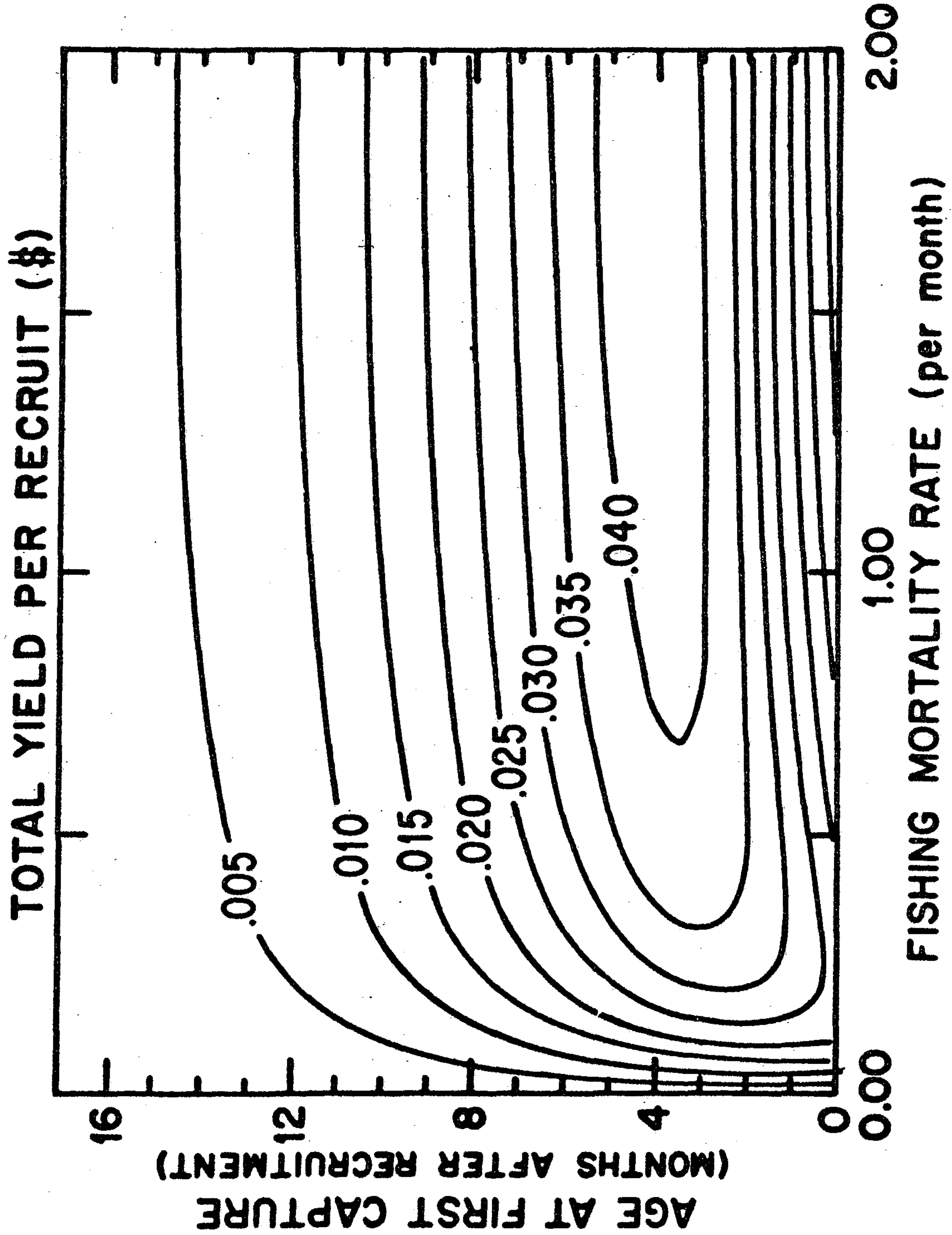

Figure 6. Yield per recruit isopleth diagram, relating "offshore" yield per recruit in grams (shrimp 2 or more months past recruitment) to "inshore" fishing mortality rates (F on first 2 months after recruitment) and "offshore" fishing mortality (F beyond 2 months past recruitment). "Current" situation (1.0, 1.0) represents 1981-1983 average, and is depicted by "+" on the figure. The dotted window approximates the region experienced by the fishery since 1960.

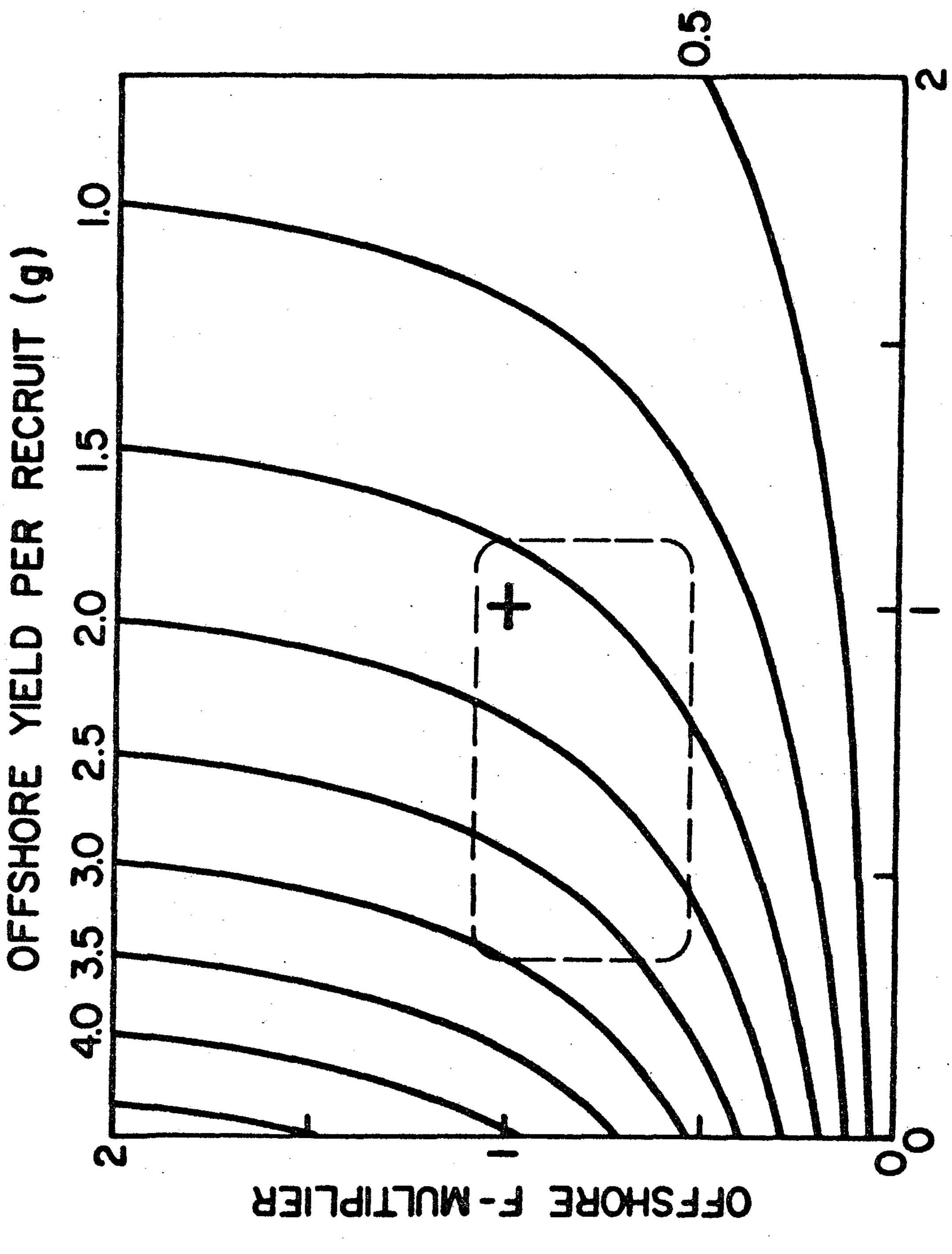

Figure 7. Yield per recruit isopleth diagram relating total yield per recruit in grams to offshore and inshore fishing mortality rates. Features are the same as for Figure 6.

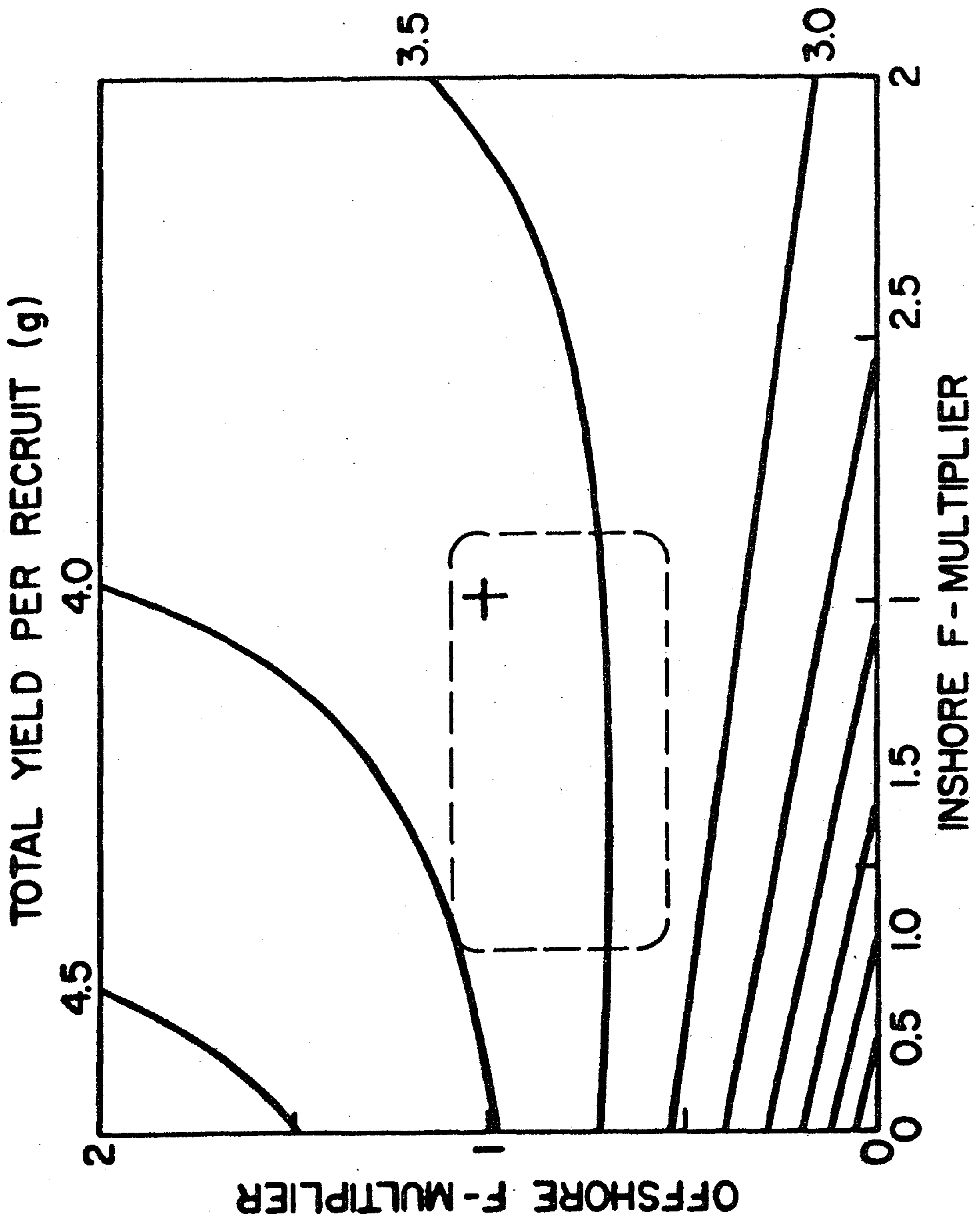

Figure 8. Yield per recruit isopleth diagram relating offshore yield per recruit in dollars (ex-vessel gross) to offshore and inshore fishing mortality rates. Features are the same as for Figure 6.

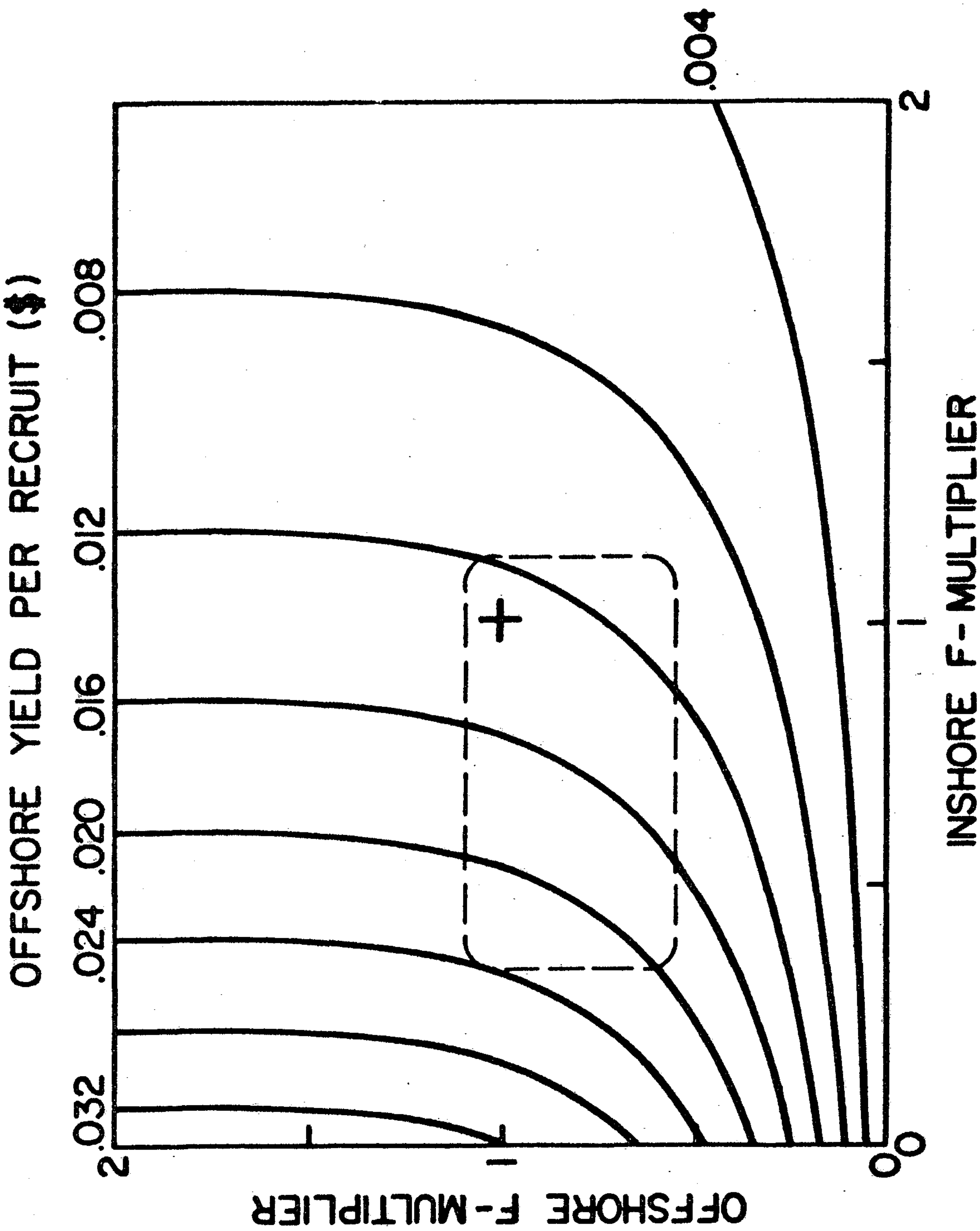

Figure 9. Yield per recruit isopleth diagram relating total yield per recruit in dollars (ex-vessel gross) to offshore and inshore fishing mortality rates. Features are the same as for Figure 6.

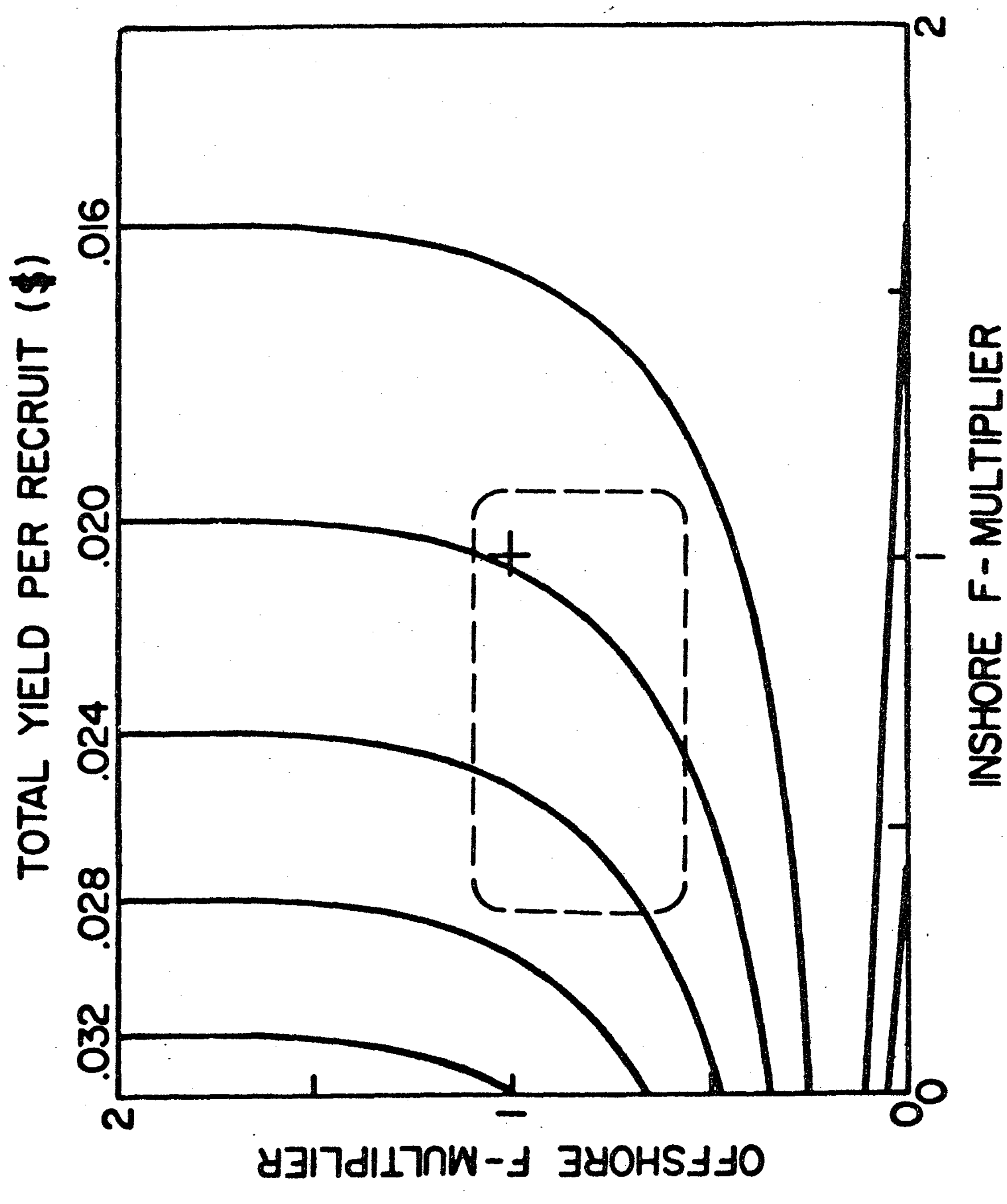

Figure 10. Average inshore/nearshore fishing mortality rate (out to 5 fm) time, 1960-1983. Values are averages for peak season (April-July) recruits for the first two months after recruitment.