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South Atlantic
Snapper Grouper Assessment 1991
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Introduction

As requested in the FY91 Operations Plan we herein report estimated present (1988) values of yield per recruit (Y/R) and spawning stock ratio (SSR) for 19 species of the snapper grouper complex. The measures represent the entire jurisdiction of the South Atlantic Fisheries Management Council, for practical purposes the Atlantic Ocean from Cape Hatteras, NC to the Dry Tortugas, FL. This report largely uses the same data and is complementary to an assessment document produced in August 1990 which provided analyses of Y/R and SSR by subregions and economic sectors of the fishery. While the original document was highly instructive about the impact of different fisheries on the resource, it did not provide a clear-cut statement of the overall status of stocks. Within the limits of the data and of necessary assumptions this report provides a region-wide perspective.

Methods

The region-wide assessment of stock status entailed, for each species, two phases:

1. construction of a region-wide estimate of catch in numbers at each age.
2. application of analytical techniques to produce estimates of current spawning stock ratio and yield per recruit.

These analyses were applied only to catch data from 1988 and assume equilibrium conditions.

Estimating Catch by Age

Estimating catch by age required consolidating six data sets:

1. Commercial landings records in weight.
2. Records of sizes of individual fish from intercept sampling of the commercial catch.
3. Estimates of catch in number by species from the MRFSS.
4. Records of sizes of individual fishes from the MRFSS.
5. Estimates of catch in number by species from the headboat survey.
6. Records of sizes of individual fishes from the headboat survey.

The procedures are, in essence, simple. For the commercial catch, total catch in weight for area and gear strata are divided by mean weights appropriate to the strata to estimate the total number of fish caught. Then catches in number for the commercial catch, as well as for the catches for the two recreational sectors which already are estimated in number, are subdivided into total catches in various length strata by multiplying a sample relative length frequency appropriate to the area-gear-strata by the total catch.

Finally age frequencies were created by arithmetically applying age-length keys to length-frequencies for subregions (so that later partitioning, if necessary, was possible) and the region-wide age frequency was established by summing the age frequencies of subregions. Thus, to the extent possible, sample size frequencies were weighted by catches pertinent to specific areas and gears before their combination.

Often there were no samples of fish sizes to apply to the commercial or MRFSS catches of certain strata (Table 1). Where data were missing we used size samples from either adjacent geographic areas, a preceding or subsequent year, or another sector of the fishery, often the headboat fishery. The determination of which adjustment to make was based on knowledge of location of fishing, trends in size for the species in question and other pertinent factors. The numerous necessary adjustments as well as all data bases and analyses supporting this document are available in file NOAA-NMFS-SEFSC-Beaufort-Reef Analysis 1991 at the Beaufort Laboratory.

For some species (e.g. scamp, gray snapper, warsaw grouper) samples of fish sizes were combined for all the years 1983 through 1988 in order to provide sufficient observations to establish a useful length frequency (Table 1). This aggregation of data will, assuming fishing mortality increased over time, cause overestimation of SSR.

Modeling Yield and Spawning Stock Ratio

Modeling of yield per recruit (Y/R) and spawning stock ratio

(SSR) was accomplished with the same procedures and routines applied by us to different sectors of the fishery in the 1990 assessment. Estimates of natural mortality rate (M) (Table 2), in general, were obtained from formulae relating M to growth parameters (Pauly 1980-81, Hoenig 1983) Estimates of age specific values of fishing mortality (F) required by the Y/R and SSR models, which are both of the Ricker type, resulted from analysis of deviations from the regression fit to the descending limb of the catch curve.

As a convention, we computed a single weighted value of F to be applied to all fully recruited age classes. The weighting factor was the estimated population at age i (N_i) subject to the age specific F_i. The estimates of N_i were derived under the equilibrium assumption from analysis of the catch curve. Because the preponderance of any population (in numbers) is in its younger age classes, the result of this weighting was to estimate F of all fully recruited age classes as being more like that of the youngest three or four fully recruited ages than like the F of the oldest age classes, which represent relatively fewer fish.

The values of age of maturity required for the models of SSR were estimated by the convention of the age of attainment of one half the asymptotic length. Both male and female biomass were included. For most species this inclusion is without effect. For the protogynous species (groupers and others) the inclusion of male biomass assumes that sperm availability could limit reproduction.

Y/R and SSR were estimated using the computer program

YRSSR.SAS (Vaughan 1990) based on Gabriel et al. (1989) and Ricker (1975).

Species included in this report are:

Black Sea Bass	Centropristis striata
Red Porgy	Pagrus pagrus
White Grunt	Haemulon plumieri
Gray Triggerfish	Balistes capriscus
Greater Amberjack	Seriola dumerili
Tilefish (Golden)	Lopholatilus chamaeleonticeps
Red Snapper	Lutjanus campechanus
Vermilion Snapper	Rhomboplites aurorubens
Gray Snapper	Lutjanus griseus
Lane Snapper	Lutjanus synagris
Mutton Snapper	Lutjanus analis
Yellowtail Snapper	Ocyurus chrysurus
Gag	Mycteroperca microlepis
Scamp	Mycteroperca phenax
Black Grouper	Mycteroperca bonaci
Speckled Hind	Epinephelus drummondhayi
Warsaw Grouper	Epinephelus nigritus
Snowy Grouper	Epinephelus niveatus
Red Grouper	Epinephelus morio

Discussions are of total length unless otherwise specified (e.g. as for gray triggerfish).

Results

Overview

The consolidation of data sets resulted, for most species, in almost textbook-perfect catch curves. The descending limbs of the age frequencies commonly were smooth curves. Even species (especially gag and scamp) that had presented troubling and unconventional catch curves in earlier analyses had classic curves here. As usual, those species for which larger samples of lengths were available (e.g. lane snapper, black sea bass) displayed the most uniform curves.

The apparent low variability of points around the descending limb of these curves tempts speculation that for many species the assumption of equilibrium conditions is appropriate. Radically varying recruitment ought to reflect in variation about the smooth curve. Historically fluctuating levels of fishing also ought to produce visible variability. However, trending levels of fishing or recruitment will not be readily discerned from inspection of the catch curves.

A major assumption embedded in the catch curve analysis concerns that of constant recruitment for those year classes appearing in the catch curve. Violation of this assumption, if trends occur, will result in biased estimates of fishing mortality and SSR. If recruitment is trending upwards, then older fish (recruited earlier) will be under-represented compared to younger fish (recruited more recently). Hence, estimated fishing mortality will be biased upwards, and resultant estimates of yield per recruit and spawning stock ratio will be too low. If recruitment is trending downwards, the converse results: estimated fishing mortality will be biased downwards, and estimates of yield per recruit and spawning stock ration will be too high. If there is no trend the variation in recruitment merely results in variance about the estimates not in bias.

Trends in fishing mortality may also bias the results. Increasing fishing mortality, which is almost certainly the case for much of our reef fishery, results in underestimates of F and overly optimistic estimates of SSR. While exact measures of overall fishing effort are difficult to construct, most would agree that there are more participants in the reef fishery then there were a decade ago, and it is universally acknowledged that improvements in vessel speed and marine electronics (LORAN C and inexpensive fathometers) have greatly increased the effectiveness of fishermen.

Another major assumption concerns that of a single stock. To the extent that catches come from multiple, independent substocks, overfishing in some substocks may bee masked (fishing mortality underestimated) by "underfishing" in other substocks. That is, as some substocks are fished out, fishing pressure shifts to other substocks that have not as yet been heavily fished. This can lead to an underestimate of the fishing mortality rates, and overestimate of yield per recruit and spawning stock ratio. If our combined data represents only a portion of a stock for which mixing is slow, estimated fishing mortality from this subarea may either under-represent, over-represent, or by happenstance accurately represent the overall level of fishing mortality of the entire stock.

For most species, overall regional estimates of SSR and present Y/R predominantly reflect values resulting from recreational fishing as reported in the 1990 assessment. The estimates are of course affected more by numbers of fish caught than by weight caught and given that recreational fisheries, by and large, take smaller fish of a species, a recreational fishery of less poundage than a simultaneous commercial fishery can influence

SSR and Y/R values more. In particular, inclusion of the MRFSS data, with the associated very large, non-headboat recreational catches, often had a dramatic effect on region wide estimates of SBR.

Overall, nine of 19 species have SSR values of less than 0.30, the criterion value designating overfishing. Another four species have values of from 0.34 to 0.30, very close to the criterion level, while 16 of 19 species have SSR values at 0.38 or less. Of the remaining three species the SSR value for greater amberjack, 0.79, is highly suspect because of the unusual distribution of sampled sizes.

We realize that there are variances associated with these estimates and that in truth an estimate of 0.28 may not be different than one of 0.30, or for that matter, 0.35. Indeed the true SSR value for some species that appear "safe" (SSR >0.30) may actually be less than 0.30. However, given ignorance of the variances we have no choice but to use the point estimates with caution.

To provide a further overview of the snapper-grouper resource we computed weighted (both by number caught and weight caught) average SSR values for the group as a whole. While these values have limited predictive value and probably cannot be interpreted precisely, we believe they provide a useful general guide to the state of the resource. Weighted by number (and excluding values pertaining to greater amberjack) or weight caught the overall SSR is 0.28. Relative to the Council's minimum acceptable state both are clearly indicative of the depressed condition of the resource as a whole.

Finally, as is mentioned several times in subsequent text, the projected value of size limits is based on the assumption that survival of released undersize fish is complete. As mortality of released fish increases, the effect of the size limit in increasing SSR diminishes. The diminution could be offset by a still greater size limit which in turn would have to be adjusted to account for the longer period of the fish's life when it is too small for legal retention and subject to mortality upon release. Ultimately if release mortality is too high (the exact situation varies by species and levels of fishing mortality), SSR can only be increased by reducing fishing mortality.

Species Accounts

Black Sea Bass

The 1988 equilibrium SSR is 0.34 and the Y/R is 79% of the maximum (Figs. 1 and 2). The current and proposed eight inch total length (TL) (age 3.5 years) size limit will provide an SSR of 0.48 at current F and should maintain an SSR of at least 0.30 (with total survival of released fish) even if F increases threefold.

Red Porgy

The present SSR is only 0.11 and about 80 percent of the maximum Y/R is being taken (Figs. 3 and 4). Vaughan et al. (in press) estimated equilbrium SSR off the Carolinas (for both sexes) in 1980 as 0.65 with a decline to 0.27 by 1987. To achieve an SSR of 0.30 will require reducing F by 51 percent or, with total survival of released fish, establishing a minimum size of 15 (14.4) inches. A 12 inch size limit will provide an SSR of only 0.15 (Table 3), and only if F does not increase. A 15 inch size limit in addition to providing an acceptable SSR will also increase Y/R by a modest 15 percent. Achieving the 51 percent reduction in F requires reducing the catch to approximately 303,000 individuals or 262 mt (from 535 mt) (Table 4).

White Grunt

The 1988 equilibrium SSR for white grunt (Figs. 5 and 6) was 0.17 and realized Y/R was 80 percent of the maximum. A 34 percent reduction in F or a size limit of 11 inches is required to achieve an SSR of 30%. Based on 1988 catches, the required reduction in F amounts, approximately, to reducing the catch from one millon individuals (373 mt) to about 660,000 fish weighing 246 mt. A small gain in Y/R (approximately 8 percent) will result from an 11 inch size limit. A 12 inch size limit will yield an SSR of over 40% but almost no gain in Y/R. White grunt appear to be one of the most difficult species to release alive. Thus size limits may not be effective for them.

Gray Triggerfish

In 1988 the region wide equilibrium SSR for gray triggerfish (Figs. 7 and 8) was 0.30. Establishing any size limit up to about

11 inches (fork length) provides no substantial gain in SSR. Greater size limits allow substantial increases in SSR if those are desired. No large gains in Y/R are available.

Greater Amberjack

Data available for 1988 resulted in a computed SSR of 0.79 for greater amberjack (Figs. 9 and 11). If this value were true the population is in excellent condition. Our suspicions are that the unusual catch curve for amberjack (Fig. 10) represents either poor sampling of the population by the fishery, poor sampling of the fishery by biologists, or both. The first of these is probably the most important effect. Whereas samples from the headboat and commercial fishery have a modal age of two with declines thereafter, the MRFSS data, which represent large catches of amberjack, have a modal age of four. Combining all the data result in a catch curve and models that are difficult to interpret.

Tilefish

Despite other data and knowledgeable opinion indicating that tilefish populations are severely depleted the 1988 SSR was 0.31 (Figs. 12 and 13), a value slightly greater than the overfishing criterion. The commercial fishery (the catch is virtually entirely commercial) first takes tilefish at about age seven. High recruitment ages essentially guarantee high SSR values. As expected, the SSR reflects most closely the value computed in 1990 for north Florida, presently the location of the greatest landings.

If tilefish were significantly reduced by fishing effort and then fishing effort was subsequently reduced, then the SSR calculated on present F could be quite high with the population still depleted and the spawning stock at very low levels. This is the situation with Georges Bank haddock (Joseph Powers, NMFS, Miami, personal communcation).

Red Snapper

Red snapper (Figs. 14 and 15) displayed the lowest SSR, 0.08, of any frequently-caught species. F must be reduced by 57% to achieve an SSR of 30 percent (to approximately 104,000 individuals from the present 229,000). A 19 inch size limit is required to produce SSR of 30%. Major gains in yield per recruit will come from a size limit. At present F, 0.42, a 98 percent gain in yield per recruit will result from the 19 inch size limit necessary to produce the 30 percent SSR.

A 20 inch size limit will allow maintenance of an SSR of 0.30 despite a small (20 percent), increase in F (0.42 to 0.50) and at present F will result in a 107 percent increase in Y/R. Based on an examination of headboat catches, it appears that the proposed bag limit of two red snappers will have a negligible effect (<2 percent) on reducing F.

Vermilion Snapper

For vermilion snapper (Figs. 16 and 17) the SSR is 0.23. A 49 percent reduction in F (from 0.79 to 0.40) is required to provide an SSR of 30%. Establishing a minimum size of 13 inches will bring the SSR to 30% and increase Y/R very slightly (six percent). A size limit of 15 inches would preserve an SSR of 0.30 or better despite increases in F and would produce a 25 percent increase in yield per recruit at present F. Increasing F offers either small gains (at high recruitment ages) or losses (at low recruitment ages) in yield per recruit. A 10 inch size limit without reduction in F will yield an SSR of 0.26. A 10 fish bag limit will (based on headboat data) produce a 25 percent reduction in the recreational catch or an overall reduction in F of approximately 11 percent. Based on a crudely weighted combination of the two proposed size limits (10 inch-recreational and 12 inch commercial) and the 10 fish bag limit, the SSR should be about 0.28 overall.

Gray Snapper

Gray snapper (Figs. 18 and 19) exhibits the second lowest SSR (0.12) of any snapper and the third lowest of any frequently taken species. To achieve an SSR of 30 percent F must be reduced by 47 percent (from the present 0.34) or a size limit of 16 inches applied. The necessary reduction in F entails (approximately) curtailing the catch from 1.2 million individuals (508 mt) to about 640,000 fish. The proposed twelve inch size limit results in an

SSR of only 0.14. The proposed 10 snapper aggregate limit will provide an as yet unmeasured reduction in F for gray snapper. Where yellowtail and lane snapper are abundant the reduction in F could be significant assuming that lesser fish are not discarded when a larger gray snapper is taken.

Lane Snapper

Like all the snappers primarily associated with south Florida, lane snapper *(Figs. 20 and 21) has an SSR greater, much greater in* this case, than 0.30. For lane snapper SSR is 0.58 and there appears no pressing need for regulation. If F increases from the present 0.45 to about 0.6 a 22 percent gain in yield per recruit could occur with a size limit of six inches (equivalent to an age of one year). The proposed size limit of eight inches provides an SSR of >0.30 even if F increases threefold.

Mutton Snapper

The SSR from mutton snapper (Figs. 22 and 23) appears to be 0.38. While this value exceeds the overfishing criterion it does not correlate well with reports from many fishermen who perceive the resource as substantially depleted.

Of many possible explanations for this anomaly, these are salient:

1. We have grossly erred in estimating parameters used in the models. M or K could be overestimated or the age at first maturity underestimated. We are unaware of data to suggest

we erred greatly.

2. Our samples of sizes of fish may not represent well the catch or the population. This explanation seems somewhat unlikely because the sample size was large (n=1150) and the sampling was well distributed over time.

3. The true biological criterion for overfishing of mutton snapper may be greater than an SSR of 0.30.

4. The assumption of equilibrium may have been violated. Low recruitment in recent years can reduce the slope of the catch curve and apparent F.

And finally there may be no anomaly at all. The opinions of the fishermen may be based on a poorly drawn sample and not be representative of the overall population. The proposed 12 inch size limit should result in an SSR of 0.44 at present F and SSR should remain above 0.3 even if F increases 30 percent to about 0.22.

Yellowtail Snapper

The equilibrium SSR for yellowtail snapper (Figs. 24 and 25) in 1988 was 0.38. Again no pressing need for regulation appears, nor are any important gains in Y/R available by establishing a minimum size if F remains at present levels (0.28). The existing 12 inch size limit will provide an SSR of 0.55 at present F (0.28) and should maintain the SSR at >0.30 against at least a tripling of F.

Gag

Of three groupers of the genus Mycteroperca included in this assessment two have SSR values exceeding the overfishing criterion and the value for one (scamp) is slightly below. SSR for the gag (Figs. 26 and 27) is 0.32, marginally greater than the overfishing criterion. Essentially no gain in Y/R is available by establishing a size limit if F remains at 0.29, but a 19 percent gain could be had (as always, with total survival of released fish) if F increases by 50 percent to 0.48 and a size limit of 30 inches were established. That combination would yield an SSR of about 80 percent. The proposed 20 inch TL size limit provides an SSR of >0.30 only for F <0.35, a value about 20 percent greater than F in 1988.

Scamp

For scamp (Figs. 28 and 29) the SSR is 0.28. A mere six percent reduction in F or a size limit of 17 (16.6) inches (total length) (with total survival of released fish) will provide an SSR of 0.30. The proposed 20 inch size limit would yield a 19 percent increase in yield per recruit and an SSR of over .30 if F remains below about 0.3 (that is F may more than double). However, recall that scamp is one of the species for which size data from the commercial fishery from 1983 to 1988 were aggregated, and the commercial catch is numerically greater than the recreational catch. Thus the SSR estimate is almost certainly optimistic.

Black Grouper

SSR for black grouper (Figs. 30 and 31) as well as for two other species (mutton snapper, yellowtail snapper) limited almost exclusively to south Florida are remarkably similar (black grouper, 0.37; yellowtail and mutton snappers 0.38) tempting the belief that a regional pattern exists. Whether one does or not, it appears that none of the three species meet the Council's definition of overfished. A 20 inch size limit for black grouper will provide an 19 percent increase in Y/R and maintain the SSR at >0.30 for F <0.52, about 140 percent of current F.

Speckled Hind

SSR for speckled hind (Figs. 32 and 33) is 0.25. A 21 percent reduction in F to 0.19 is needed to achieve an SSR of 0.30. The catch would need to be adjusted downward from about 7,000 individuals (1988) to about 5,500.

Given the scale of the fishery, the imprecision of any conceivable control procedure, and the relatively minute size of the speckled hind catch it may be unrealistic to protect this species with catch limits (other than a total closure). A size limit of 16 inches would provide an SSR of 0.30 at present F (0.24) but a 20 inch size limit would be needed to assure (assuming successful releases are possible) an SSR of 0.30 if major (>50 percent) increases in F occur, and any increase in F over present would require some upward adjustment in the size limit. This species is often taken at greater depths (> 60m) and appears difficult to release alive. Further speckled hind are taken in association with species that conceivably could support a legitimate catch. Thus the unintentional catch of speckled hind could be considerable unless the catch of associated species is sufficiently limited. And finally the SSR value presented largely reflects commercial catches, and size data from commercial catches was aggregated for the years 1983-1988. Thus the SSR presented is probably an overestimate. Far less than 0.05 percent of the entire reef fish catch is of speckled hind. Given the rareness of the species and its current numerical unimportance to the catch, perhaps special goals for management of speckled hind should be considered.

Warsaw Grouper

Warsaw grouper (Figs. 34 and 35) are only slightly less rare in the estimated catch than speckled hind (9,000 vs 7,000 fish out of a total catch for the 19 studied species of 12 million in 1988). Samples of warsaw grouper lengths are very rare (n= 80, 1988) and the only aging study available was based necessarily on relatively few fish (n= 124). Based on these samples and the estimated aggregate commercial and recreational catch the SSR was 0.002 for 1988.

To achieve an SSR of 0.30 an 89 percent reduction in F appears to be required. Thus the allowable catch would be on the order of only 1,000 fish. Conversely a size limit, were it possible to apply one to these deep (> 50 fathom) dwelling fish, would need to be about 44 inches. Like the speckled hind, the warsaw grouper is apparently so rare that special goals and approaches must be employed in its management. Given that the warsaw is most often taken as a bycatch to snowy grouper and other deep dwelling species, its management may require more stringent regulation of the catch of co-occurring species than their status alone would indicate.

Snowy Grouper

The SSR for snowy grouper (Figs. 36 and 37) in 1988 was only 0.15. A 42 percent reduction in F is needed over the region as a whole to provide an SSR of 30 percent. Snowy grouper apparently live in localized units some of which are far more accessible to fishermen and far more depleted than others. Thus establishing a region-wide goal for catch reduction may not achieve a meaningful improvement in many of the substocks. The 42 percent reduction in F would allow a catch of only about 35,000 fish over the region, but it might be necessary to entirely prohibit fishing on some heavily impacted areas to allow them to achieve the mean abundance for the region and to allow the species maximum use of its original range. Area specific management would entail far more detailed examination of the geographic distribution of catches and more expensive site-oriented enforcement than now exist.

Red Grouper

Of the four Epinephelus groupers included in this assessment only one, the red grouper (Figs. 38 and 39), displayed an SSR of >0.30, in this case, 0.41. Generally occupying shallower water (15-30 fathoms) than speckled hind, snowy or warsaw groupers, red grouper appear more resilient to fishing. However, the region wide SSR must be used carefully. It largely represents huge catches of red grouper landed in the Florida Keys, many of which may not come from waters in the jurisdiction of the SAFMC (despite our attempts to expunge Gulf produced fish). Further, the regional value masks the fact that the local sub-population off the Carolinas is more severely impacted (SSR-headboat 0.24, commercial 0.34). But from the relatively simplistic region-wide perspective, the population appears to be reproductively sound and there seems to be no need for regulation of the fishery. The proposed 20 inch size limit will yield an SSR of 0.50 at current F and will maintain SSR at >0.30 against a 250 percent increase in F. Only negligible gains in Y/R result from a 20 inch size limit.

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Table 1 - Number of fish sampled for length by source.

Headboat Data 1988

Species	Carolinas	N. Florida	S. Florida
Yellowtail Snapper	37	2935	--
Lane Snapper	39	667	--
Gray Snapper	2	136	562
Vermilion Snapper	2687	2113	883
Red Snapper	207	84	5
Speckled Hind	66	1	8
Snowy Grouper	49	--	1
Warsaw Grouper	--	1	--
Black Grouper	3	2	11
Scamp	548	7	214
Red Grouper	42	33	210
Gag	445	103	70
Red Porgy	2199	19	47
White Grunt	2435	19	963
Greater Amberjack	122	10	55
Black Sea Bass	4259	1221	124
Gray Triggerfish	231	122	197
Golden Tilefish	--	--	--
Mutton Snapper	--	15	1002

Table 1 (cont.) - Number of fish sampled for length by source.

Tips Data

Species	Carolinas	N.Florida	S.Florida	Year	Geartype
Yellowtail Snapper	--	--	158	1988	HLL
Lane Snapper	--	--	93	1988	AG
Gray Snapper	--	60	--	1985-88	HLL
" "	--	--	32	" "	N
Vermilion Snapper	--	124	644	1985-88	HLL
" "	240	--	--	" "	OG
" "	440	--	--	1988	HLL
" "	640	--	--	1988	N
Red Snapper	--	536	911	1983-88	HLL
" "	129	--	--	" "	N
" "	356	--	--	1988	HLL
Speckled Hind	850	390	59	1983-88	HLL
Snowy Grouper	1043	938	417	1988	AG
" "	1035	--	--	1988	HLL
Warsaw Grouper	-->	176	<--	1983-88	All Areas
Black Grouper	--	--	167	1984-88	AG
Scamp	2696	770	--	1983-88	AG
Red Grouper	964	--	--	1983-88	AG
" "	--	--	128	1983-88	HLL
" "	--	--	109	1987	T
Gag	--	334	--	1983-88	AG
"	--	--	713	" "	HLL
"	1749	--	--	1988	AG
Red Porgy	1667	--	--	1988	HLL
White Grunt	2690	--	--	1988	HLL
Greater Amberjack	-->	155	<--	1983-88	AG
Black Sea Bass	813	--	--	1988	T
" " "	851	--	--	"	HLL
Gray Triggerfish	1455	163	--	1983-88	HLL
Golden Tilefish	--	246	230	1988	AG
Mutton Snapper	14	--	54	1989	AG

Key:
- HLL = Hand or long line
- AG = All gear
- OG = Other gear
- N = Nets
- T = Traps

Table 1 (cont.) - Number of fish sampled for length by source.

MRFSS 1988

Species	NC	SC	GA	FL
Yellowtail Snapper	—	—	—	281
Lane Snapper	—	—	—	106
Gray Snapper	3	—	—	358
Vermilion Snapper	178	4	29	14
Red Snapper	35	5	9	131
Speckled Hind	—	—	—	—
Snowy Grouper	1	—	—	1
Warsaw Grouper	1	—	—	16
Black Grouper	—	—	—	10
Scamp	72	5	—	—
Red Grouper	24	—	—	31
Gag	123	21	2	21
Red Porgy	175	29	—	—
White Grunt	164	2	—	178
Greater Amberjack	78	6	5	87
Black Sea Bass	781	277	159	85
Gray Triggerfish	31	4	—	50
Tilefish	1	—	—	—
Mutton Snapper	—	—	—	65

Table 2. Parameters Used In Analysis

Species	K	L∞	t_o	a	b	M	$t_{L_\infty/2}$	t_r
Red Porgy	0.096	763	-1.88	$2.5x10^{-5}$	2.89	0.20	5.33	4
Vermilion Snapper	0.198	627	0.128	$1.7x10^{-5}$	2.95	0.23	2.5	4
Red Snapper	0.16	975	0.0	$2.04x10^{-5}$	2.95	0.20	4.33	2
Yellowtail Snapper	0.279	450	-0.355	$6.13x10^{-5}$	2.76	0.20	2.1	3
Lane Snapper	0.134	501	-1.49	$1.0x10^{-5}$	2.65	0.40	3.68	5
Gray Snapper	0.101	890	-0.316	$2.4x10^{-5}$	2.91	0.22	6.54	4
Mutton Snapper	0.153	862	-0.579	$1.0x10^{-5}$	3.04	0.20	3.95	2
Speckled Hind	0.13	967	-1.01	$1.1x10^{-5}$	3.073	0.20	4.32	3
Snowy Grouper	0.074	1255	-1.92	$7.0x10^{-5}$	2.755	0.13	7.4	4
Red Grouper	0.167	922	0.299	$4.0x10^{-6}$	3.22	0.20	4.45	6
Warsaw Grouper	0.054	2394	-3.616	$2.09x10^{-5}$	2.98	0.10	9.22	2
Gag	0.122	1290	-1.13	$1.2x10^{-5}$	2.99	0.20	4.55	5
Scamp	0.092	985	-2.45	$2.4x10^{-5}$	2.91	0.17	5.08	4
Black Grouper	0.116	1352	-0.927	$5.55x1^{-6}$	3.14	0.28	5.05	8
Black Sea Bass	0.231	341	-0.301	$4.22x10^{-5}$	2.8	0.30	2.69	4
White Grunt	0.108	640	-1.01	$1.4x10^{-5}$	3.02	0.30	5.41	3
Greater Amberjack	0.174	1643	-0.653	$6.4x10^{-5}$	2.82	0.30	3.49	2
Gray Triggerfish	0.382	466	0.189	$2.15x10^{-5}$	2.99	0.20	1.63	4
Tilefish	0.084	907	-0.989	$1.0x10^{-5}$	3.10	0.10	7.26	12

K, L∞, t_o - Parameters of growth equation

$$L_t = L\infty\ e^{-K(t-t_o)}$$

a, b parameters of length-weight equation

$$W = a\ L^b$$

M = instantaneous natural mortality rate

$t_{L_\infty/2}$ = estimated age at sexual maturity

t_r = youngest fully recruited age.

Table 3. SSR for selected reef fishes of the U.S. South Atlantic Region.

	HB			TIP											MRFSS			Overall	Under Proposed Regulations
Species	Caro.	NFL	SFL	Caro					NFL			SFL			Caro	NFL	SFL		
				AG	HLL	N	T	OG	AG	HLL	N	AG	HLL	T					
Red Porgy	.18	.45	.19	.29														.11	0.15
Vermilion Snapper	.19	.16	.19		.28	.38		.20	.17			.27						.23	0.28
Red Snapper	.15	.05			.24	.11			.17			.55						.08	0.34
Yellowtail Snapper		.43	.40									.42			All areas .15			.38	0.55
Lane Snapper		.47	.50						.47									.58	0.59
Gray Snapper		.56	.29							.19	.32				All areas .10			.12	0.14
Mutton Snapper		.49	.47															.38	0.44
Speckled Hind	.22		.48	.37					.42			.45						.25	
Snowy Grouper	.10			.15	.25				.36			.40						.15	
Red Grouper	.24	.11	.28	.34									.45	.15				.41	0.50
Warsaw Grouper				All Areas .12														.002	
Gag	.19	.32	.30	.47					.54			.56						.32	0.34
Scamp	.18	.42		.28					.49									.28	0.42
Black Grouper			.40						.45									.37	0.42
Black Sea Bass	.15	.17	.26		.39		.40								.28	.28		.34	0.48
White Grunt	.40	.28	.13	.39											.54		.10	.17	
Greater Amberjack	.17	.18	.07	All Areas .27														.79	
Gray Triggerfish	.43	.22	.18	.36					.38									.30	
Tilefish				.35					.28			.42						.31	

TIPS GEAR TYPES

OG = Other Gear
HLL = Handline and Longline
N = Nets
T = Traps
AG = All Gear

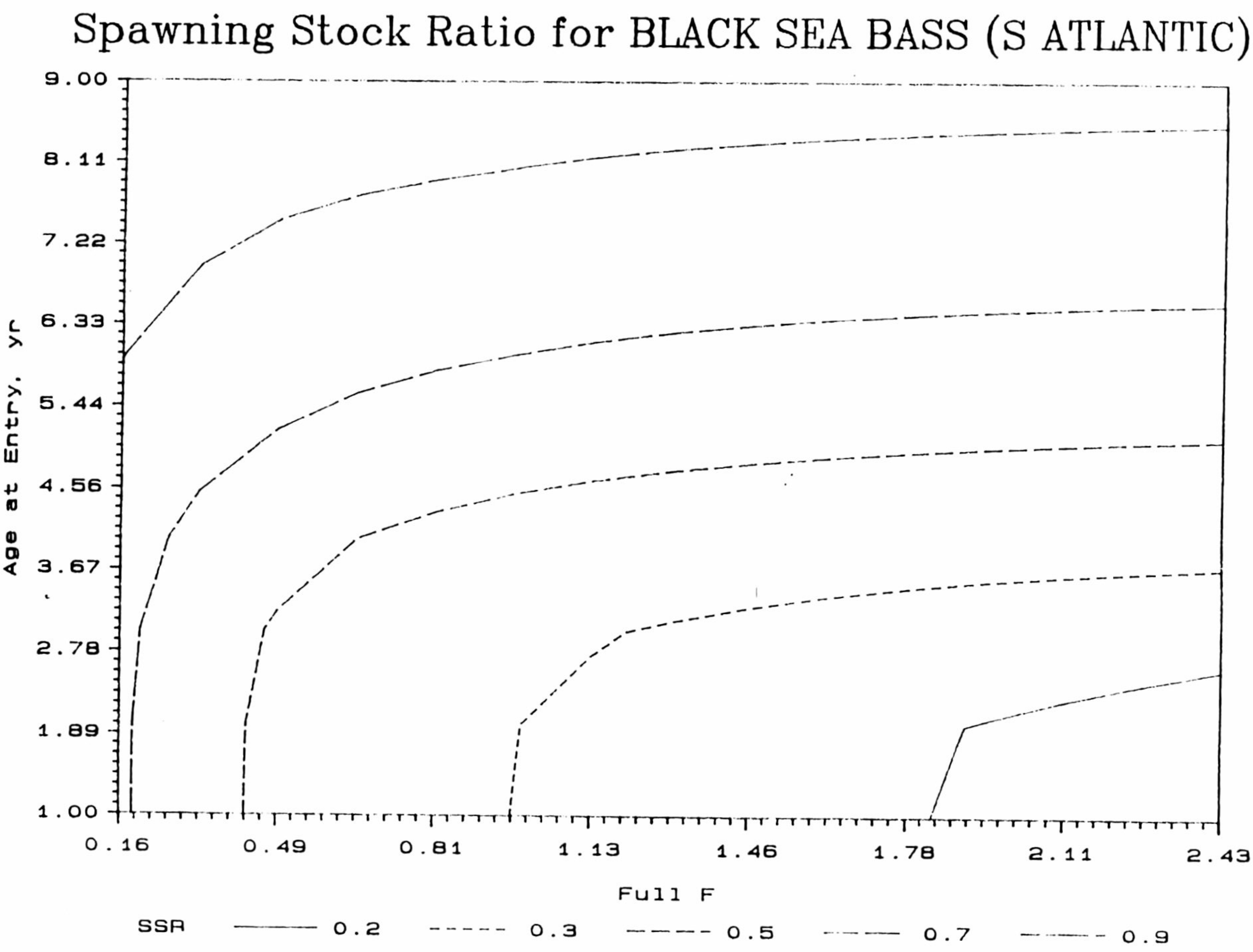
Table 4. 1988 Estimated Catch[1]

Species	Commercial Number	Commercial Weight (kg)	Headboat Number	Headboat Weight (kg)	MRFSS Number	MRFSS Weight (kg)	Total Number	Total Weight (kg)
Red Porgy	361,553	413,043	168,556	97,764	88,478	24,764	618,587	535,571
Vermilion Snapper	1,000,748	365,138	740,891	189,893	88,521	21,729	1,830,160	576,760
Red Snapper	25,872	86,386	36,527	58,999	179,085	*83,948	241,484	229,333
Yellowtail Snapper	1,013,695	633,907	285,818	181,930	381,969	217,253	1,681,482	1,033,089
Lane Snapper	82,935	27,758	115,877	37,160	258,498	40,388	457,310	105,306
Gray Snapper	551,479	209,927	35,970	45,814	650,641	252,043	1,238,090	507,784
Mutton Snapper	31,390	161,593	23,694	43,026	175,304	152,259	230,388	356,878
Speckled Hind	4,872	10,985	2,138	3,761	0	0	7,010	14,746
Snowy Grouper	56,502	169,089	953	1,488	2,621	1,735	60,076	172,312
Red Grouper	135,782	246,846	5,101	10,615	34,108	36,868	171,991	294,329
Warsaw Grouper	1,197	18,759	249	1,591	7,564	38,909	9,010	59,259
Gag	57,040	372,649	24,213	91,269	111,295	333,922	192,548	797,840
Scamp	92,012	204,098	13,975	23,590	9,205	*8,320	115,192	236,008
Black Grouper	66,007	224,051	2,290	9,353	21,926	7,072	90,223	240,476
Black Sea Bass	986,728	369,941	1,030,012	288,132	1,588,262	582,993	3,605,002	1,241,066
White Grunt	308,261	154,841	335,520	123,221	379,010	94,861	1,022,791	372,923
Greater Amberjack	120,558	438,882	10,592	76,462	76,052	402,596	207,202	917,940
Gray Triggerfish	20,287	38,587	34,926	31,670	81,318	21,192	136,531	91,449
Tilefish	55,735	299,095	-	-	1,047	2,093	56,782	301,188

* Estimated weight does not correspond to estimated number of fish.

[1] Tip and MRFSS estimates occasionally are adjusted. Such adjustments are usually minor and will not materially affect results presented in this document.

Figure 1



Spawning Stock Ratio for BLACK SEA BASS (S ATLANTIC)
9.00
8.11
7.22
6.33
5.44
4.56
3.67
2.78
1.89
1.00
Age at Entry, yr
0.16
0.49
0.81
1.13
1.46
1.78
2.11
2.43
Full F
SSR
0.2
0.3
0.5
0.7
0.9

Figure 2

Ricker Yield per Recruit for BLACK SEA BASS (S ATLANTIC)

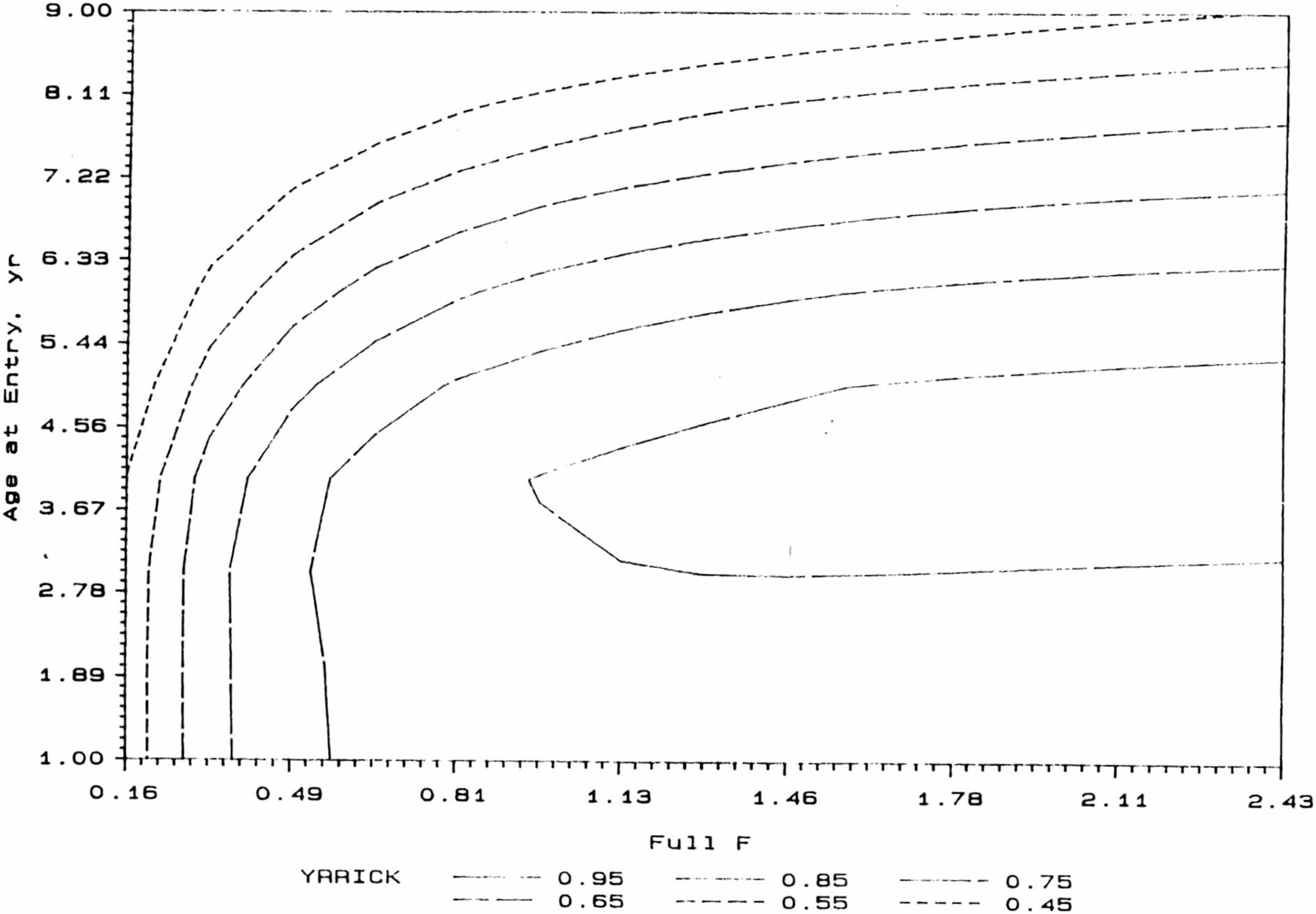
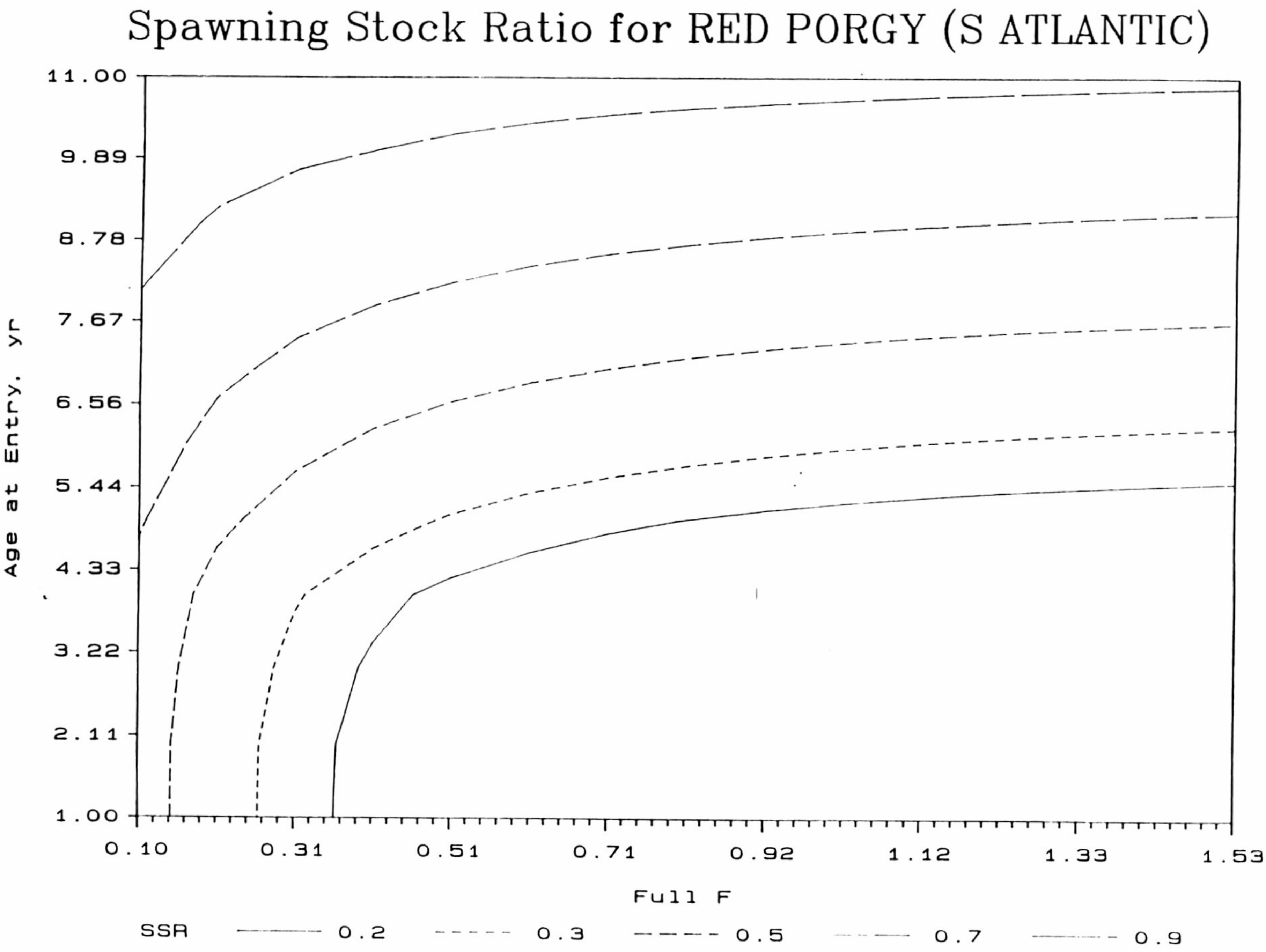


Figure 3



Spawning Stock Ratio for RED PORGY (S ATLANTIC)
11.00
9.89
8.78
7.67
6.56
5.44
4.33
3.22
2.11
1.00
Age at Entry, yr
0.10
0.31
0.51
0.71
0.92
1.12
1.33
1.53
Full F
SSR
0.2
0.3
0.5
0.7
0.9

Figure 4

Ricker Yield per Recruit for RED PORGY (S ATLANTIC)

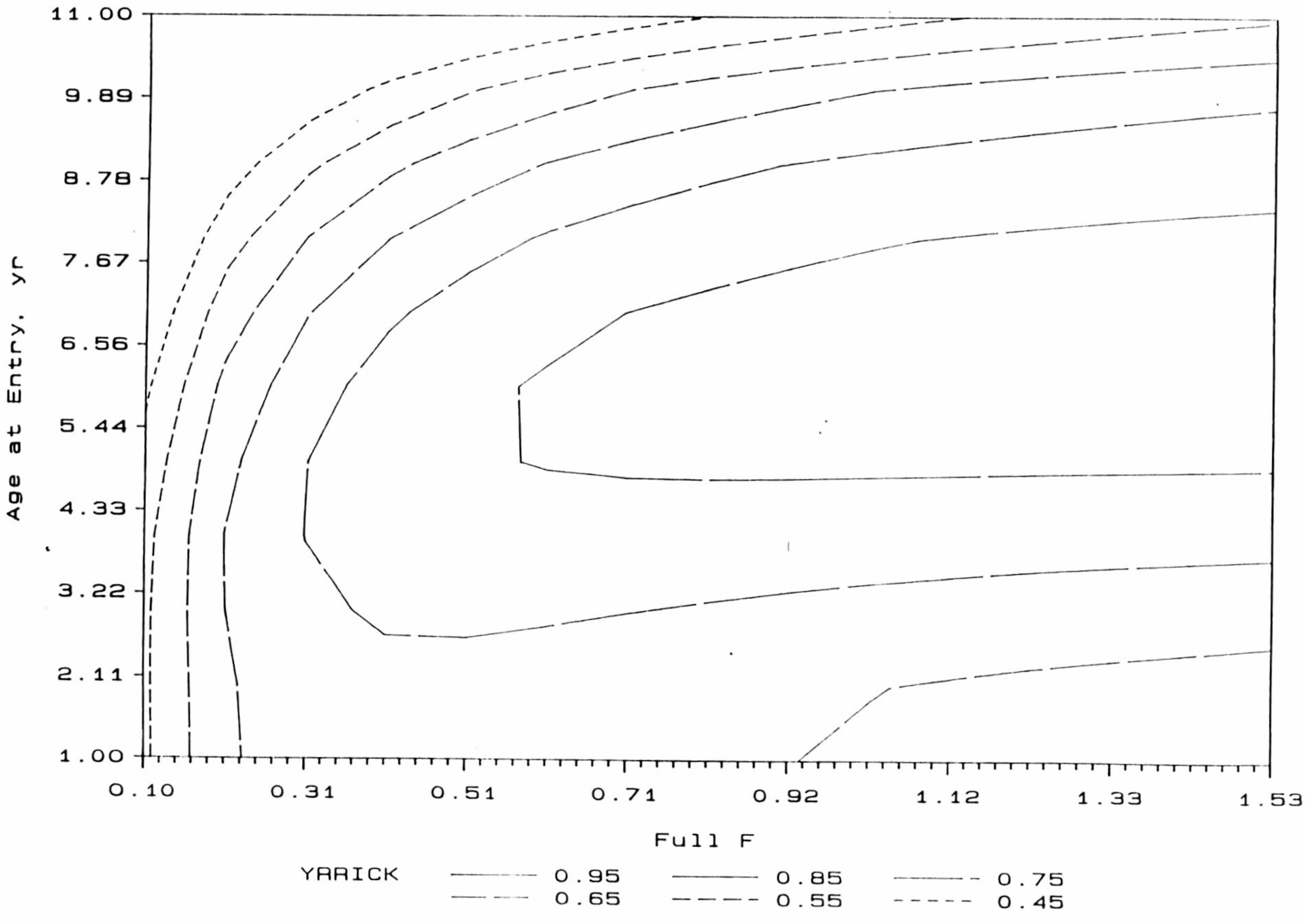


Figure 5

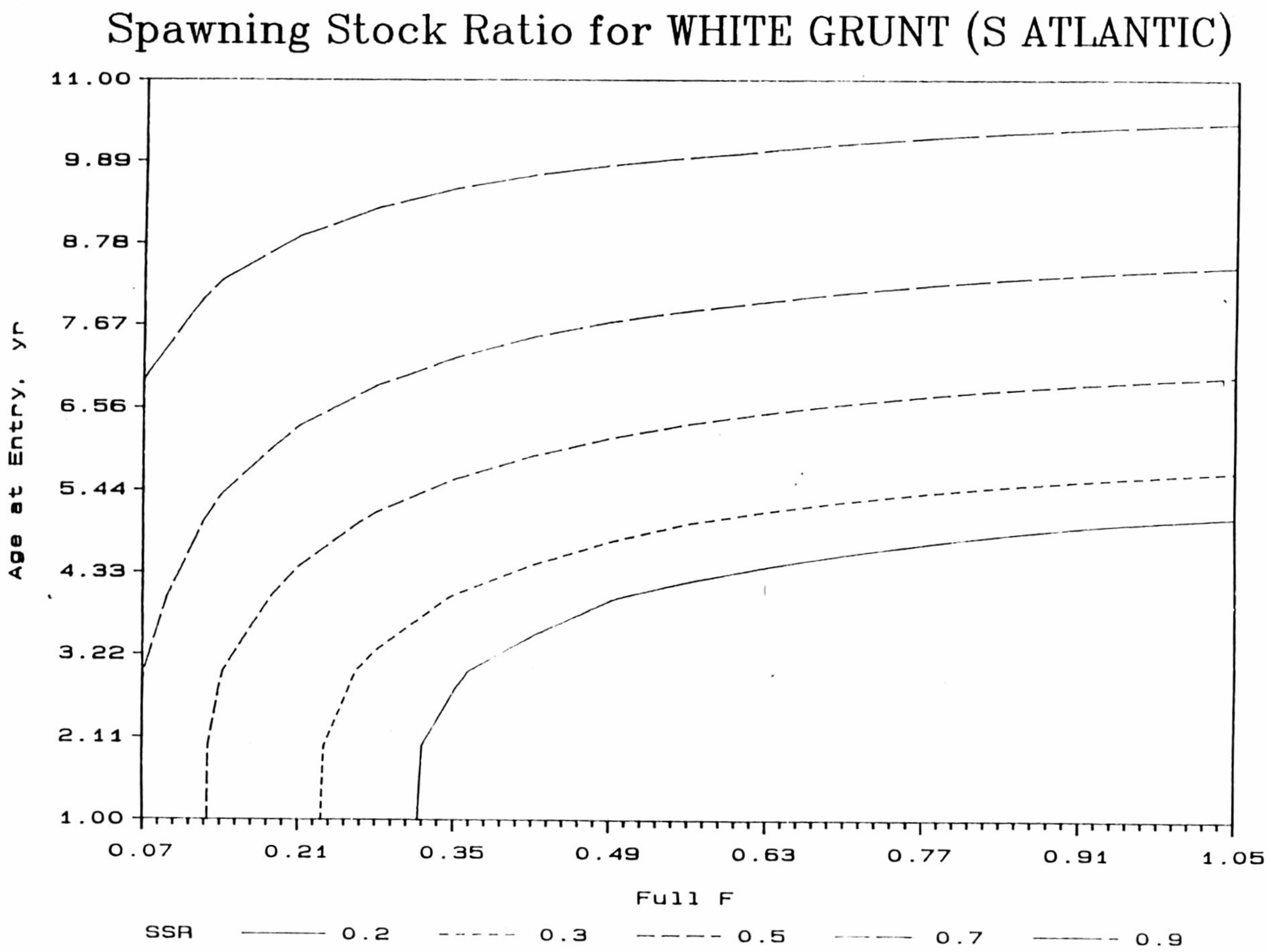

Spawning Stock Ratio for WHITE GRUNT (S ATLANTIC)
11.00
9.89
8.78
7.67
6.56
5.44
4.33
3.22
2.11
1.00
Age at Entry, yr
0.07
0.21
0.35
0.49
0.63
0.77
0.91
1.05
Full F
SSR
0.2
0.3
0.5
0.7
0.9

Figure 6

Ricker Yield per Recruit for WHITE GRUNT (S ATLANTIC)

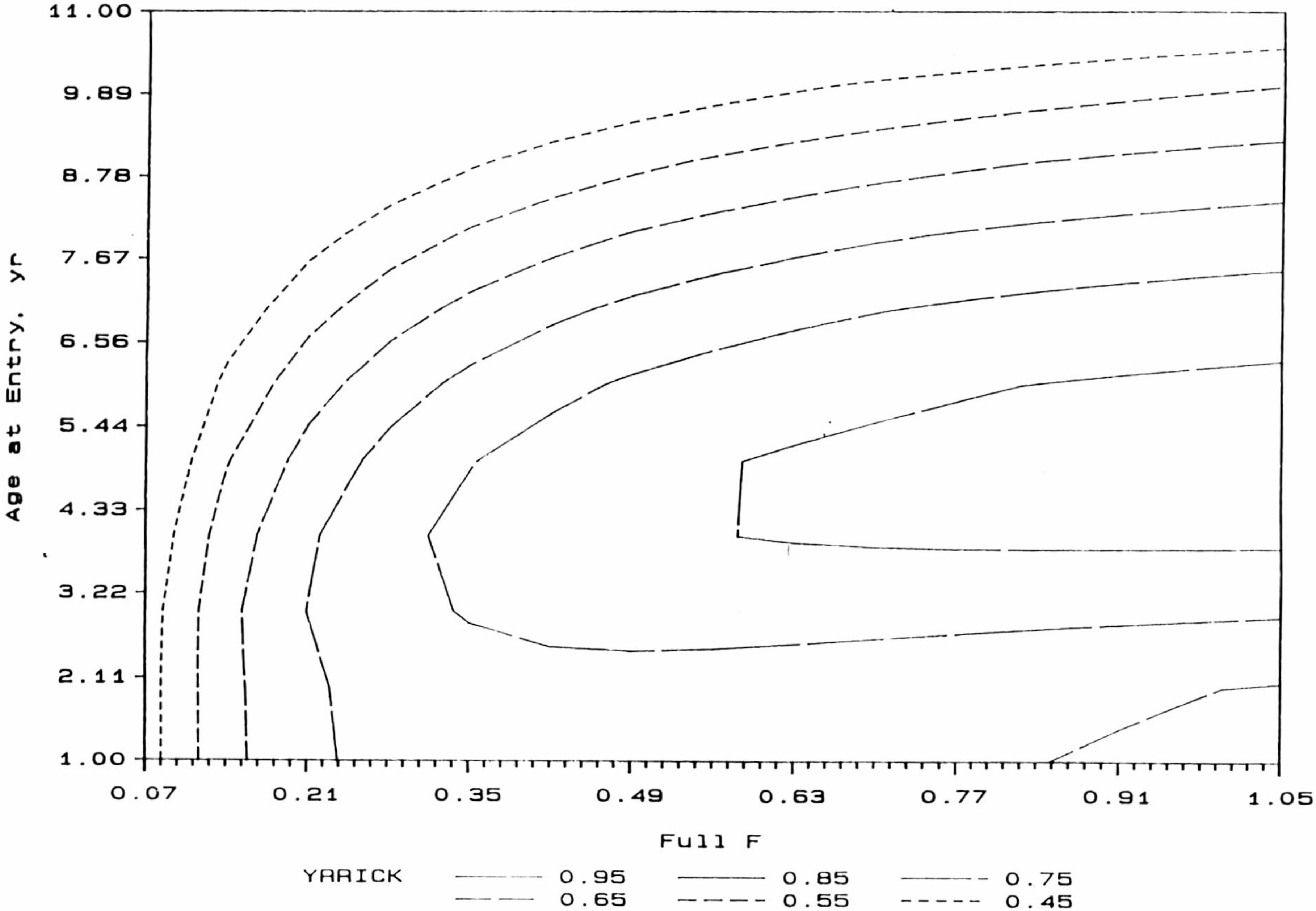


Figure 7

Spawning Stock Ratio for GRAY TRIGGERFISH (S ATLANTIC)

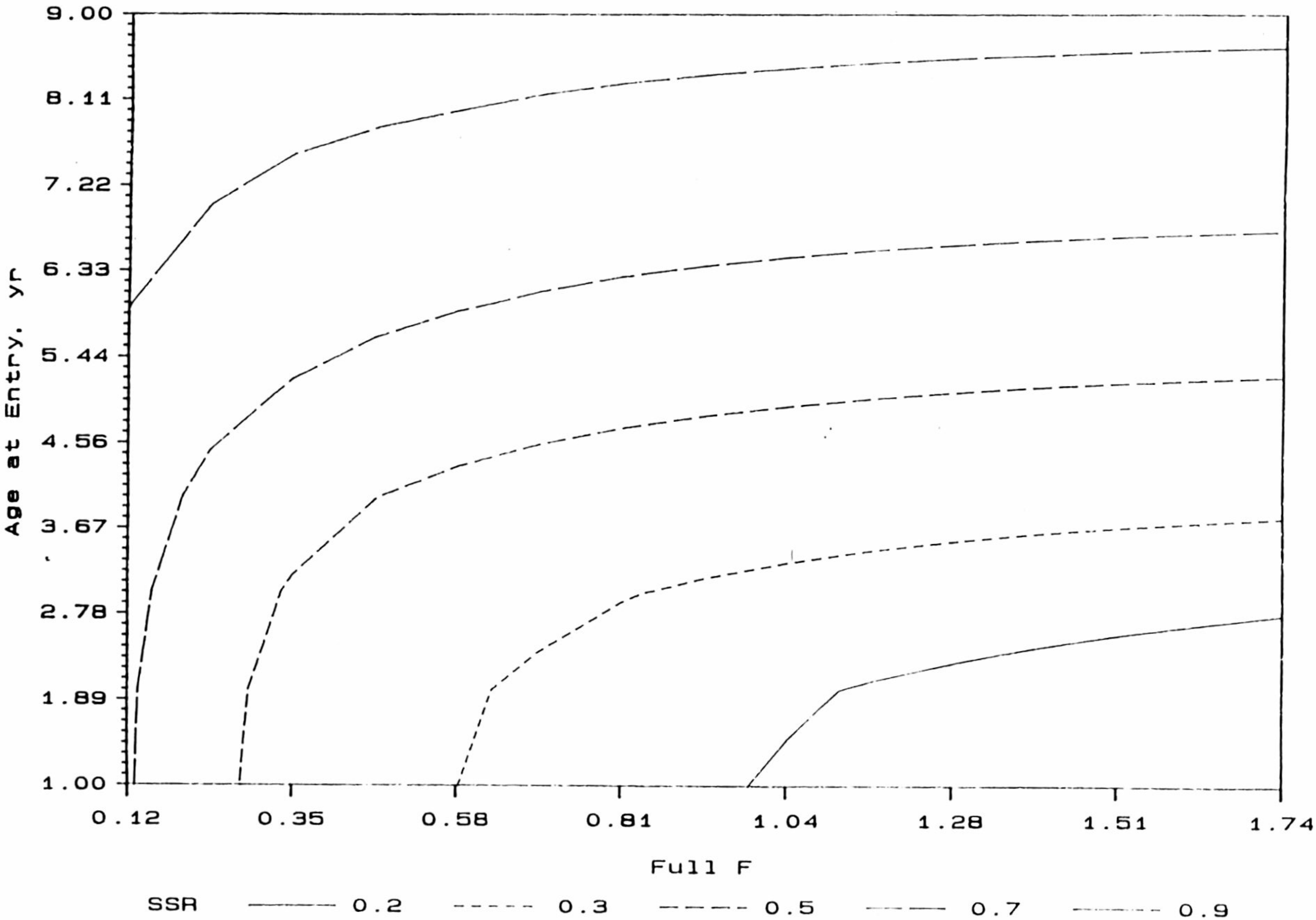


Figure 8

Ricker Yield per Recruit for GRAY TRIGGERFISH (S ATLANTIC)

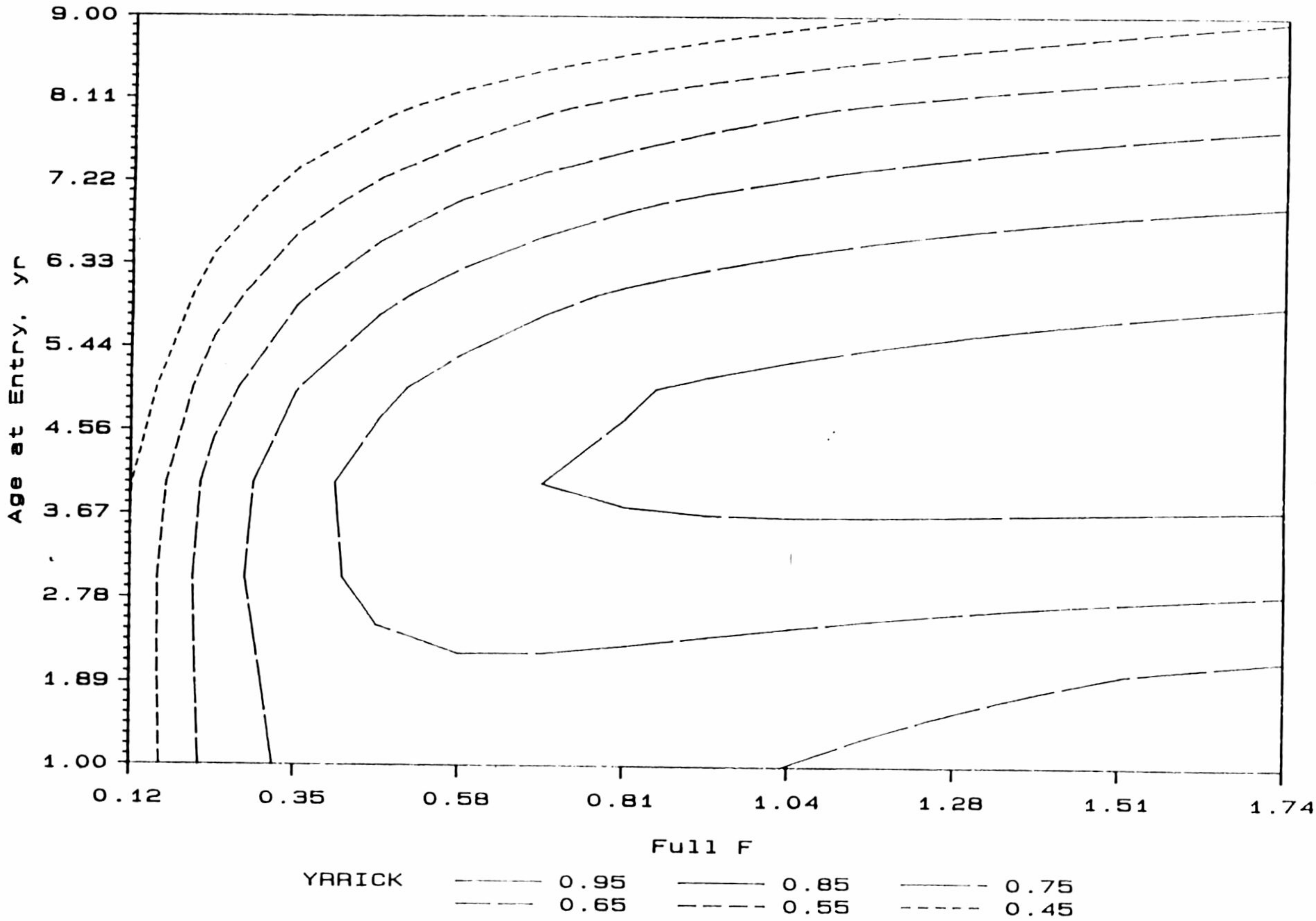


Figure 9

Spawning Stock Ratio for GREATER AMBERJACK (S ATLANTIC)

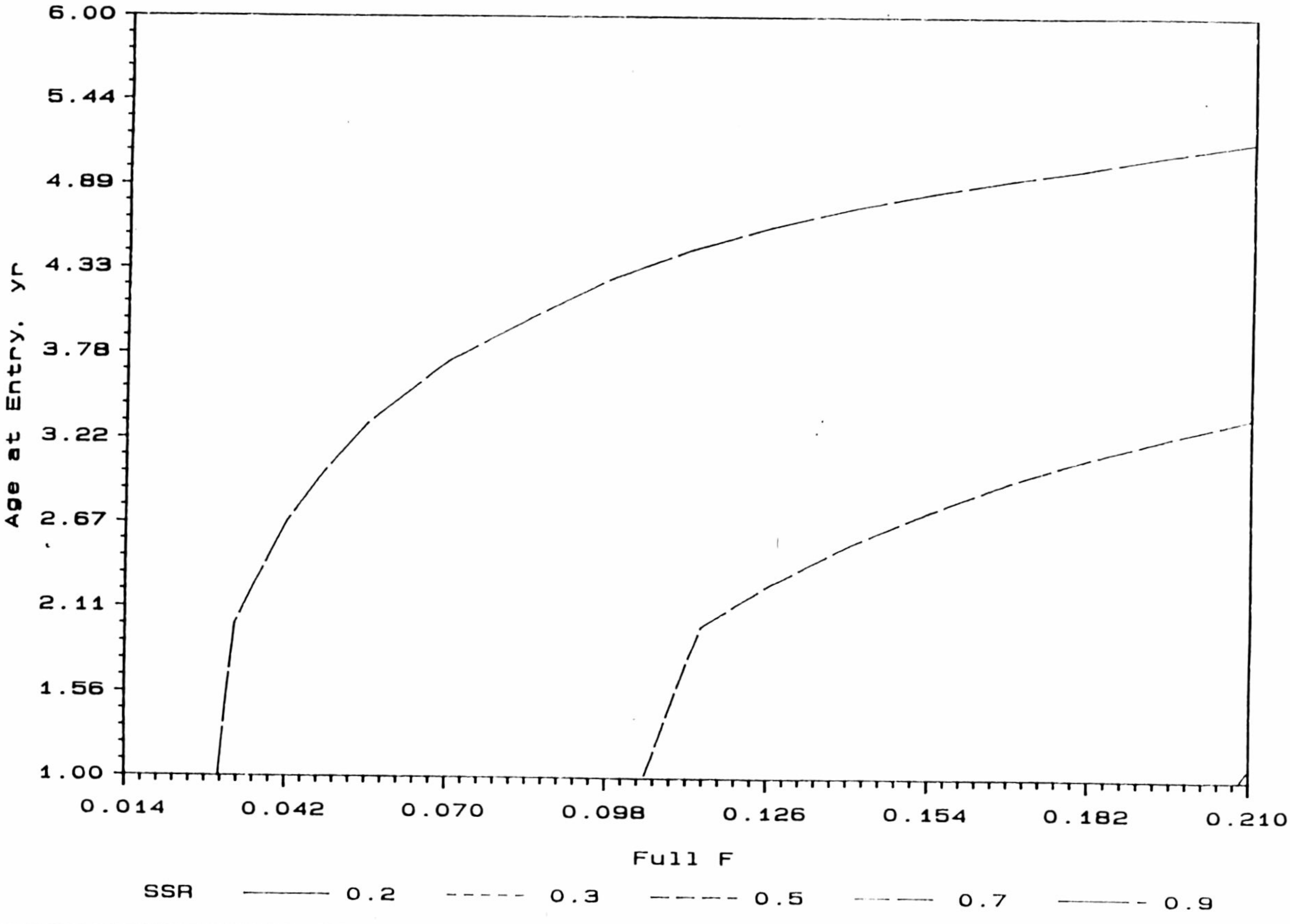


Figure 10

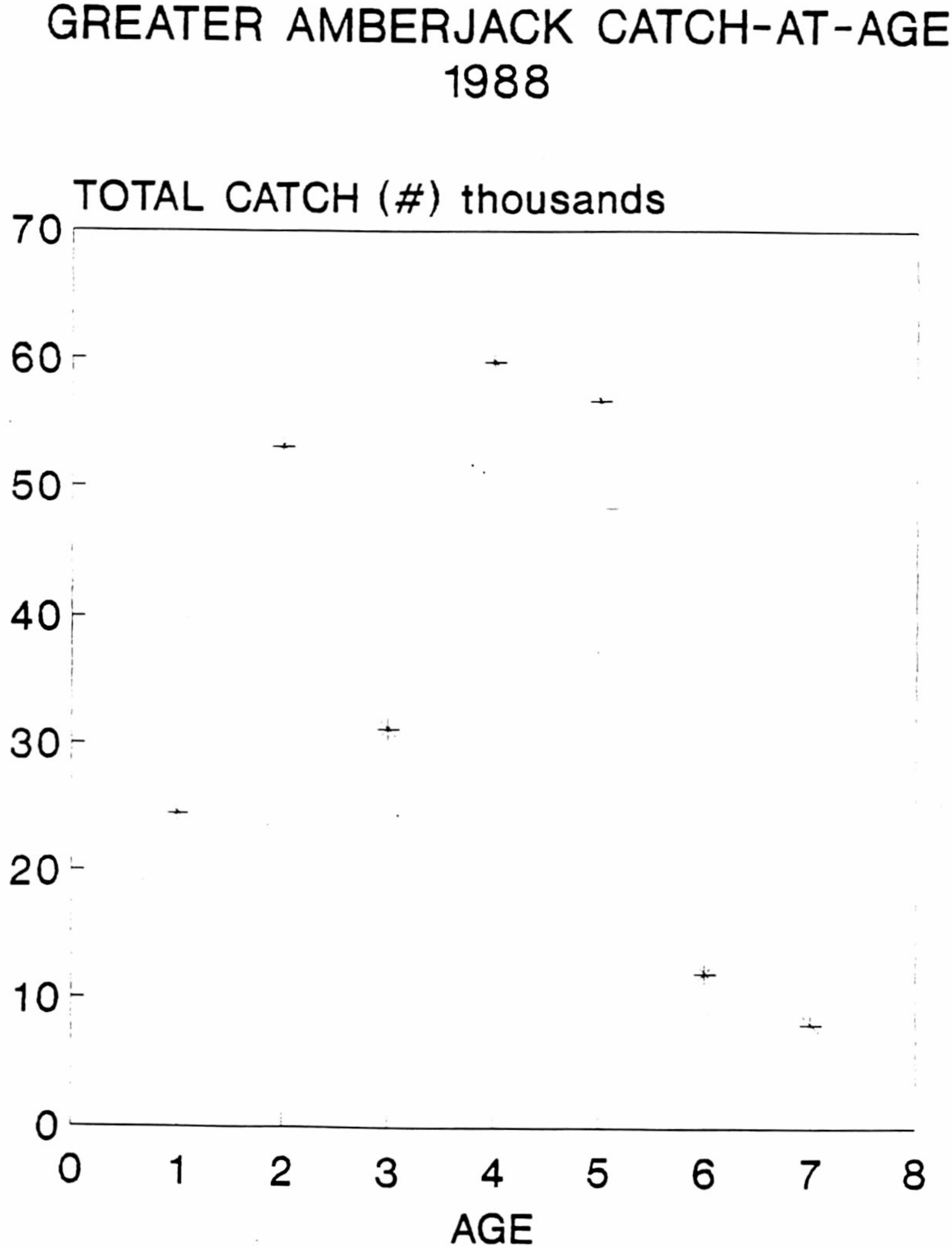

GREATER AMBERJACK CATCH-AT-AGE
1988
TOTAL CATCH (#) thousands
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
AGE

Figure 11

Ricker Yield per Recruit for GREATER AMBERJACK (S ATLANTIC)

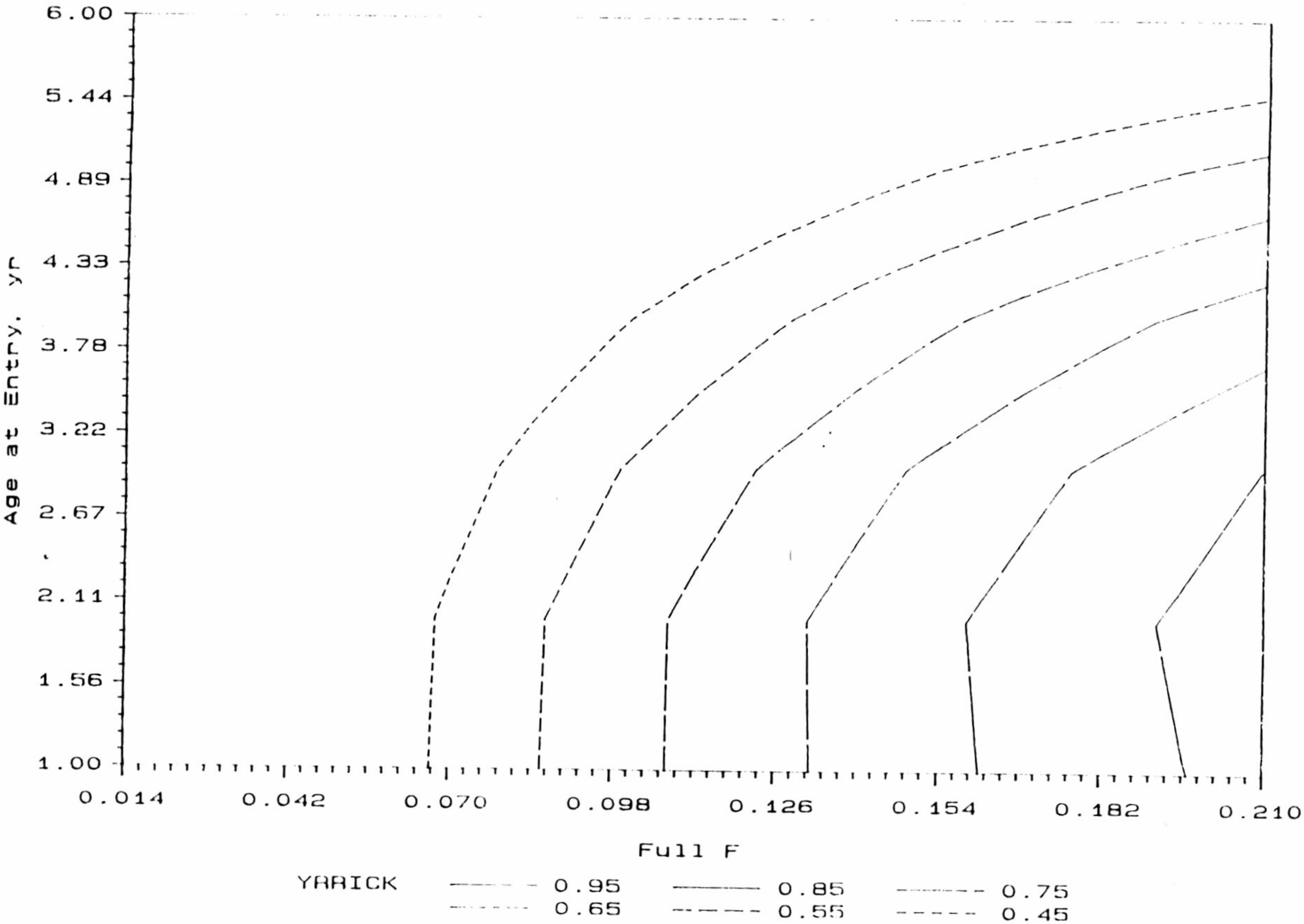


Figure 12

Spawning Stock Ratio for TILEFISH (S ATLANTIC)

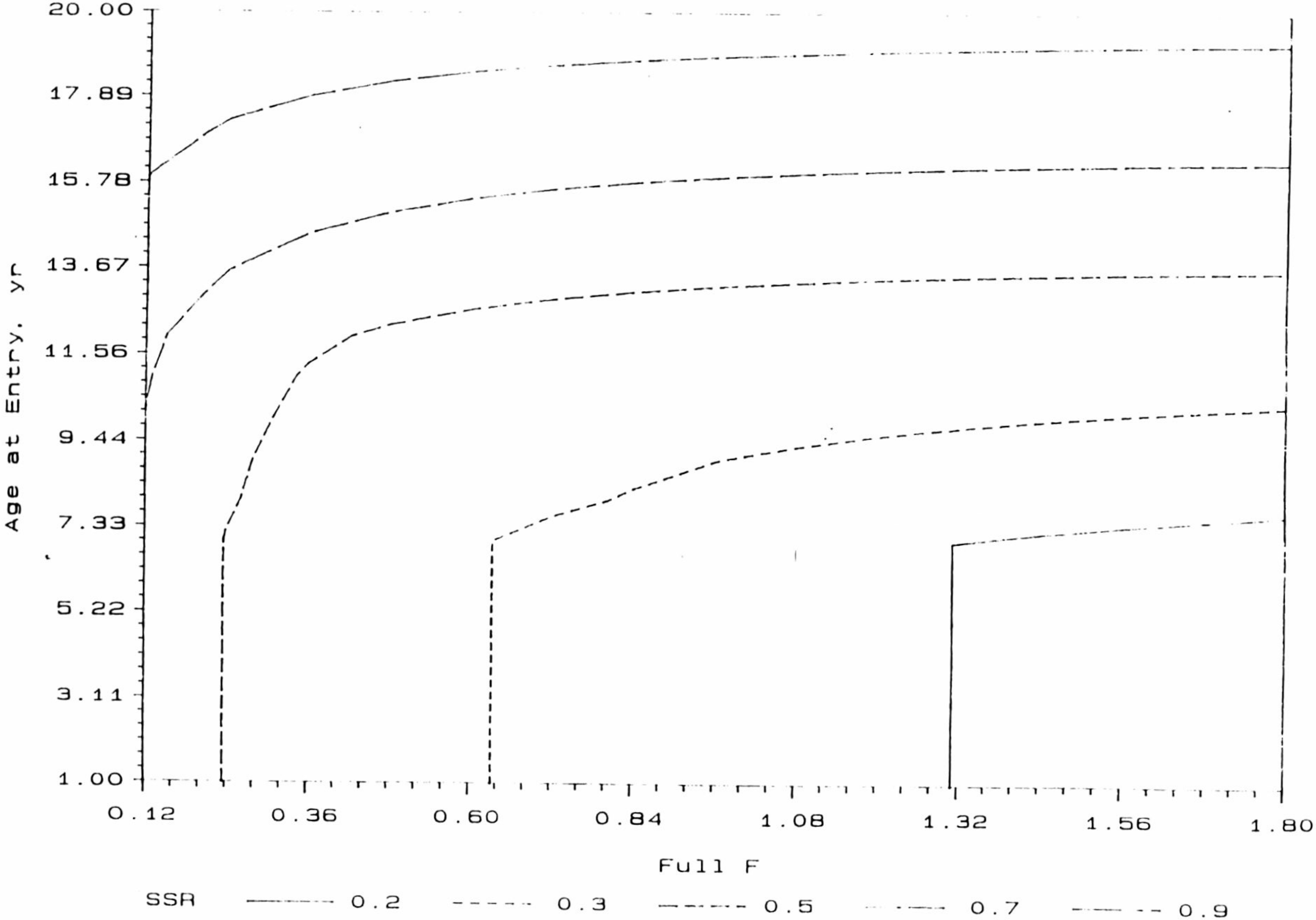


Figure 13

Ricker Yield per Recruit for TILEFISH (S ATLANTIC)

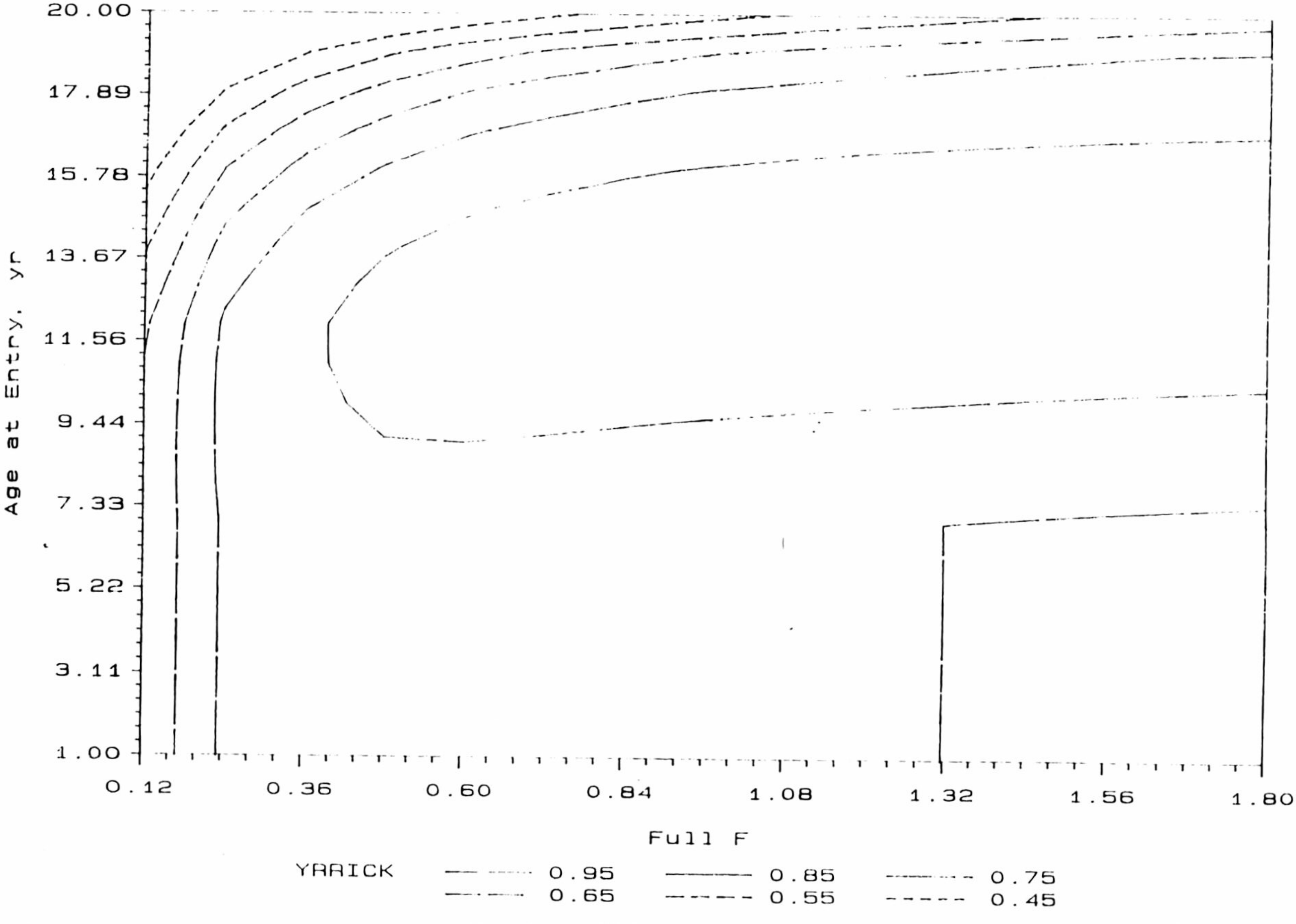


Figure 14

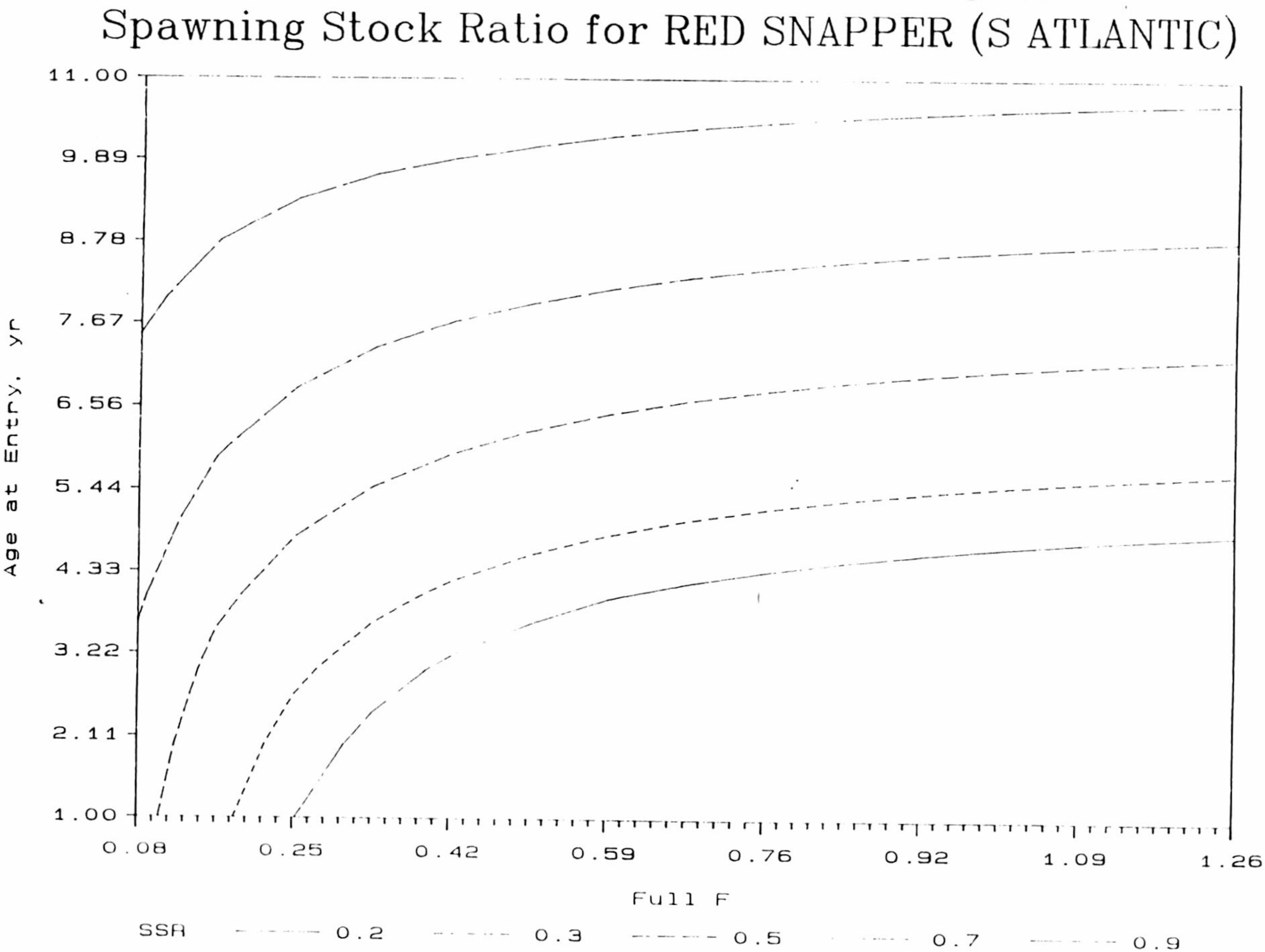

Spawning Stock Ratio for RED SNAPPER (S ATLANTIC)
11.00
9.89
8.78
7.67
6.56
5.44
4.33
3.22
2.11
1.00
Age at Entry, yr
0.08
0.25
0.42
0.59
0.76
0.92
1.09
1.26
Full F
SSR
0.2
0.3
0.5
0.7
0.9

Figure 15

Ricker Yield per Recruit for RED SNAPPER (S ATLANTIC)

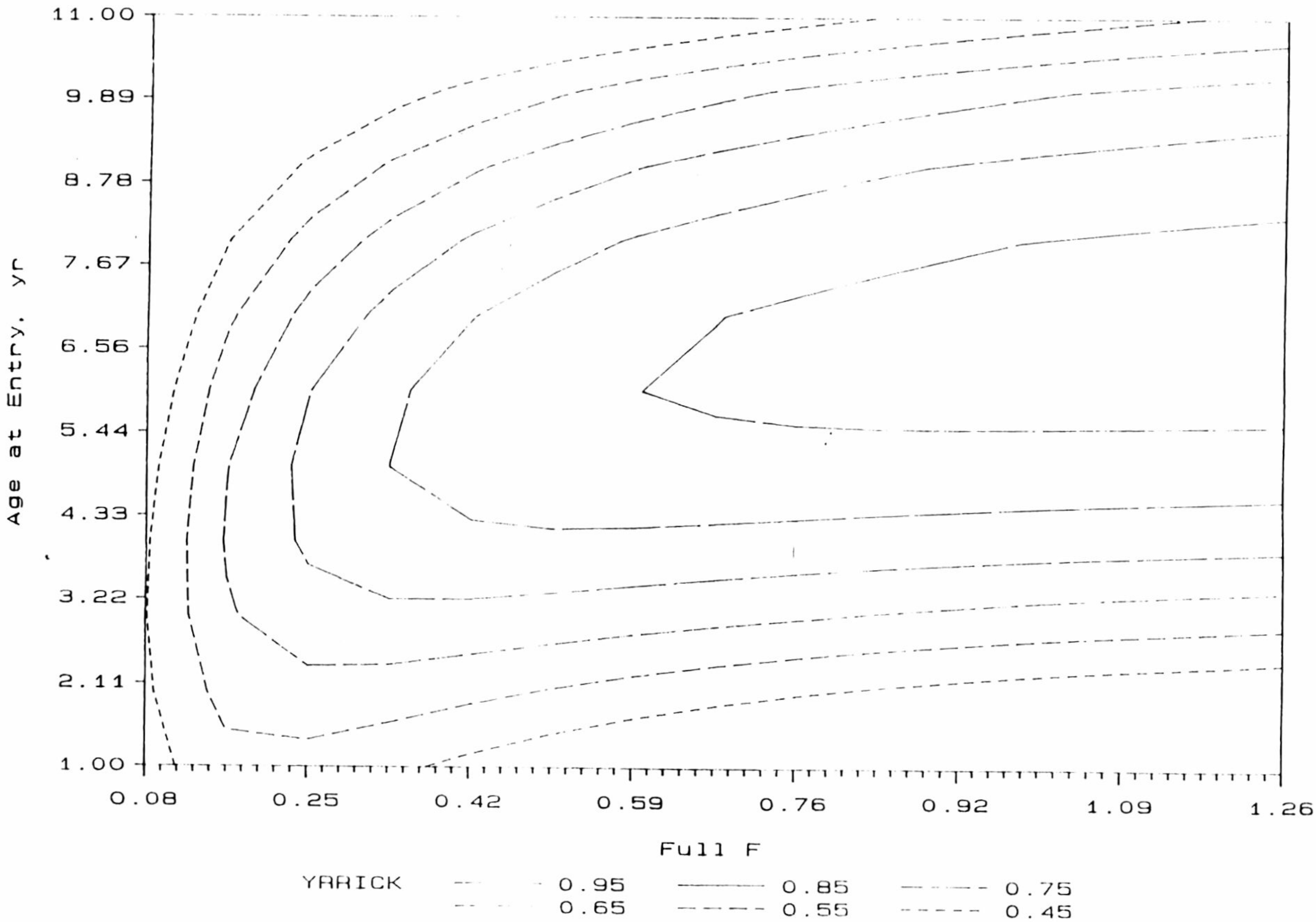


Figure 16

Spawning Stock Ratio for VERMILION SNAPPER (S ATLANTIC)

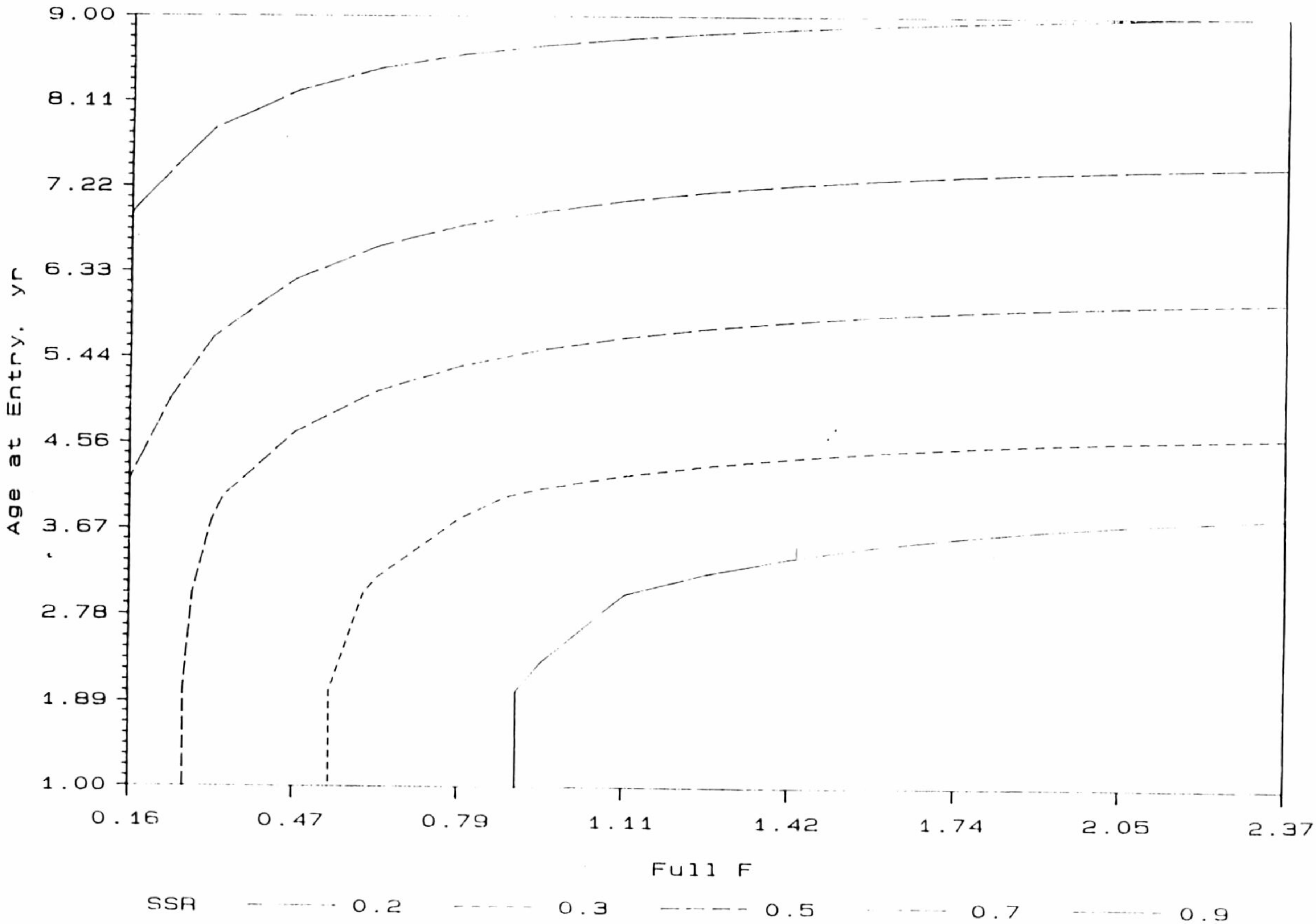
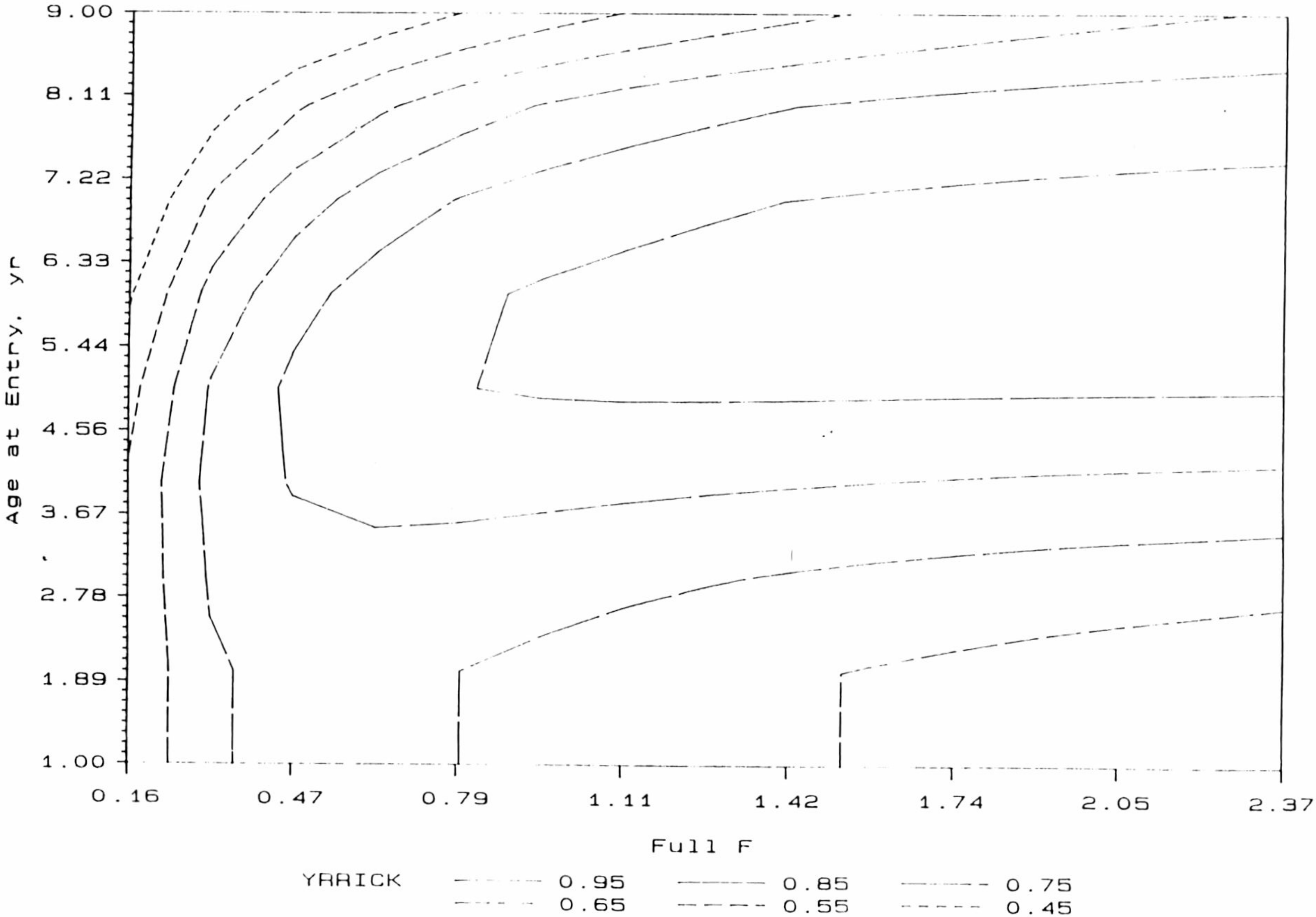


Figure 17

Ricker Yield per Recruit for VERMILION SNAPPER (S ATLANTIC)



Spawning Stock Ratio for GRAY SNAPPER (S ATLANTIC)

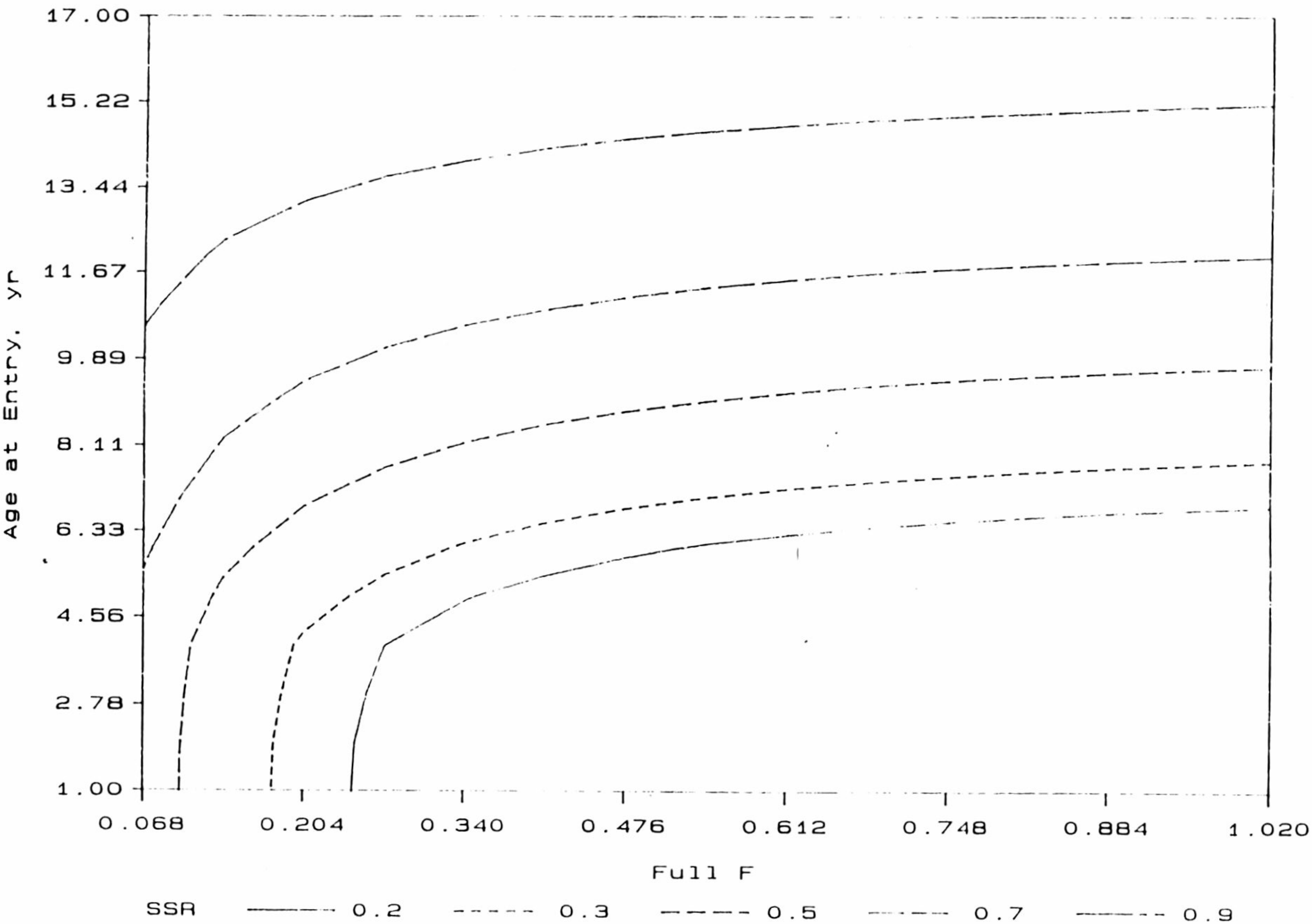


Figure 19

Ricker Yield per Recruit for GRAY SNAPPER (S ATLANTIC)

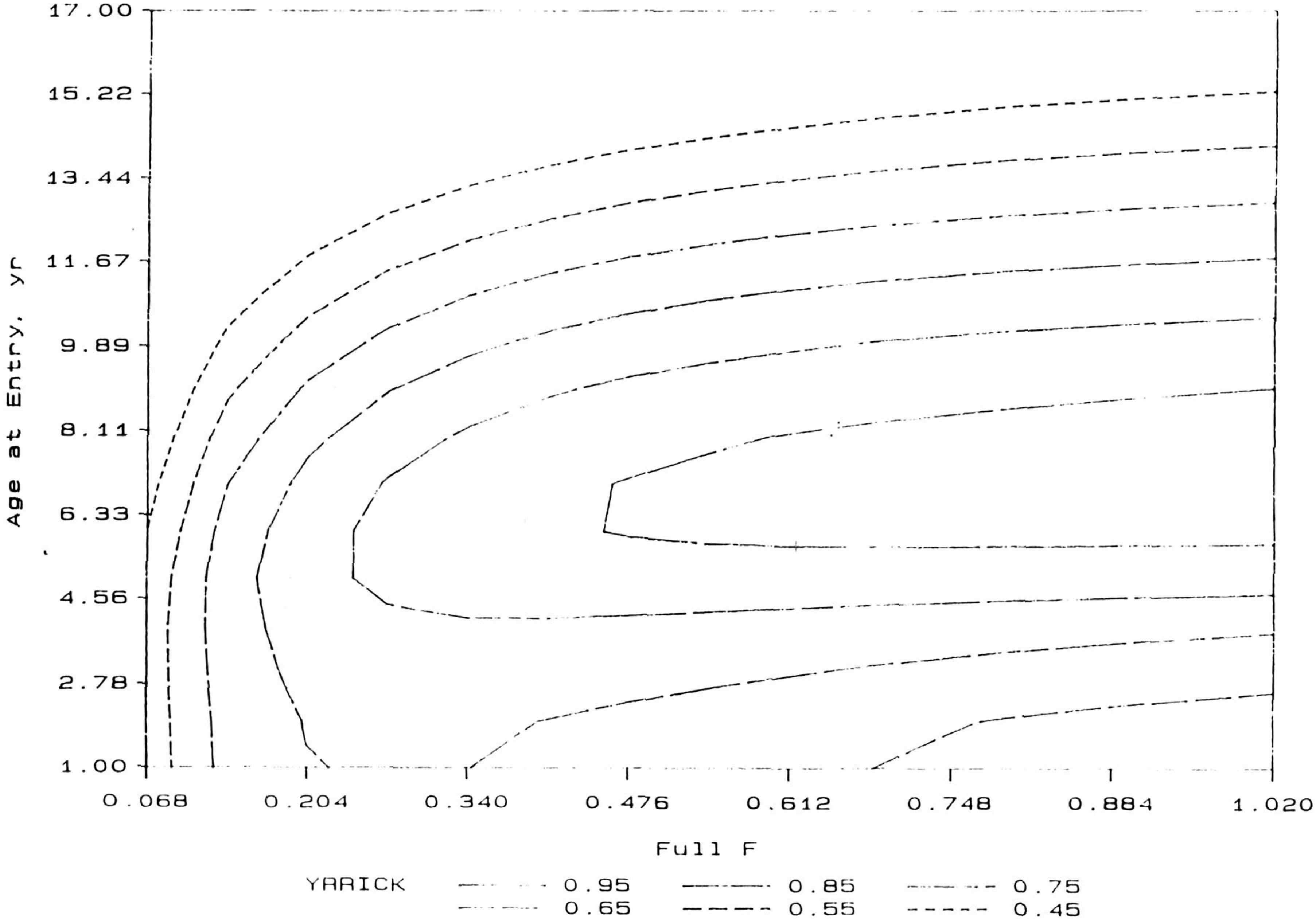


Figure 20

Spawning Stock Ratio for LANE SNAPPER (S ATLANTIC)

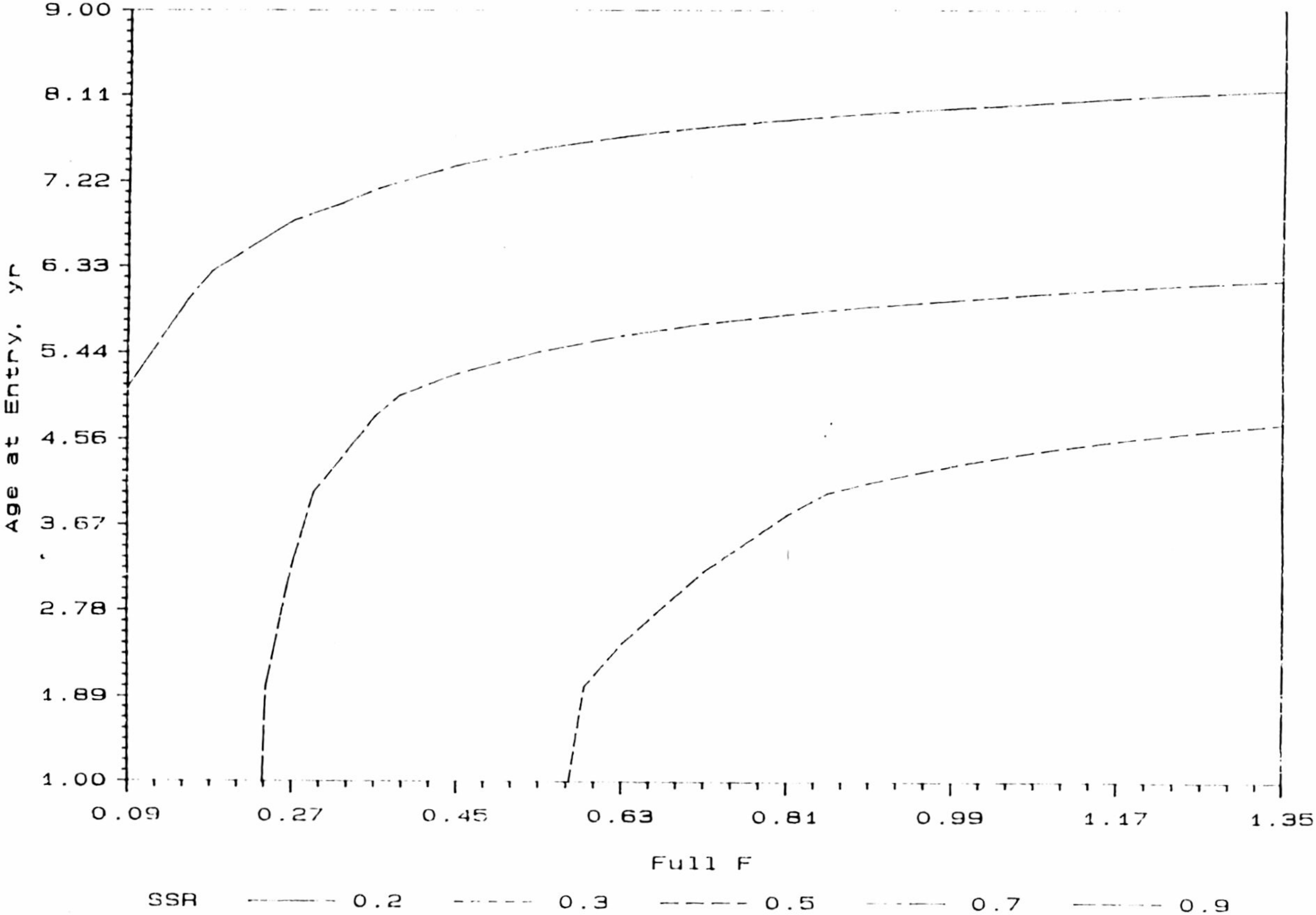


Figure 21

Ricker Yield per Recruit for LANE SNAPPER (S ATLANTIC)

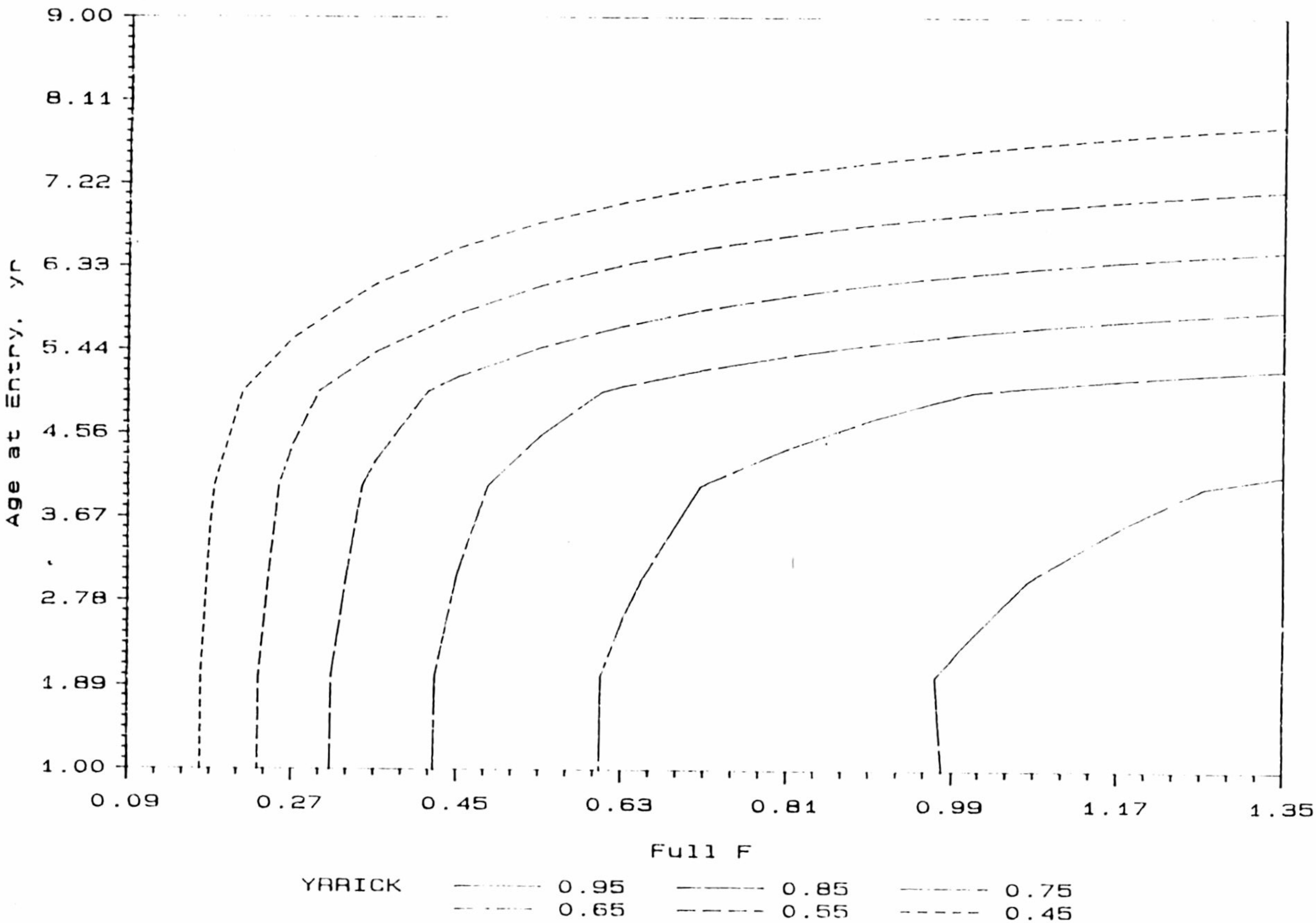


Figure 22

Spawning Stock Ratio for MUTTON SNAPPER (S ATLANTIC)

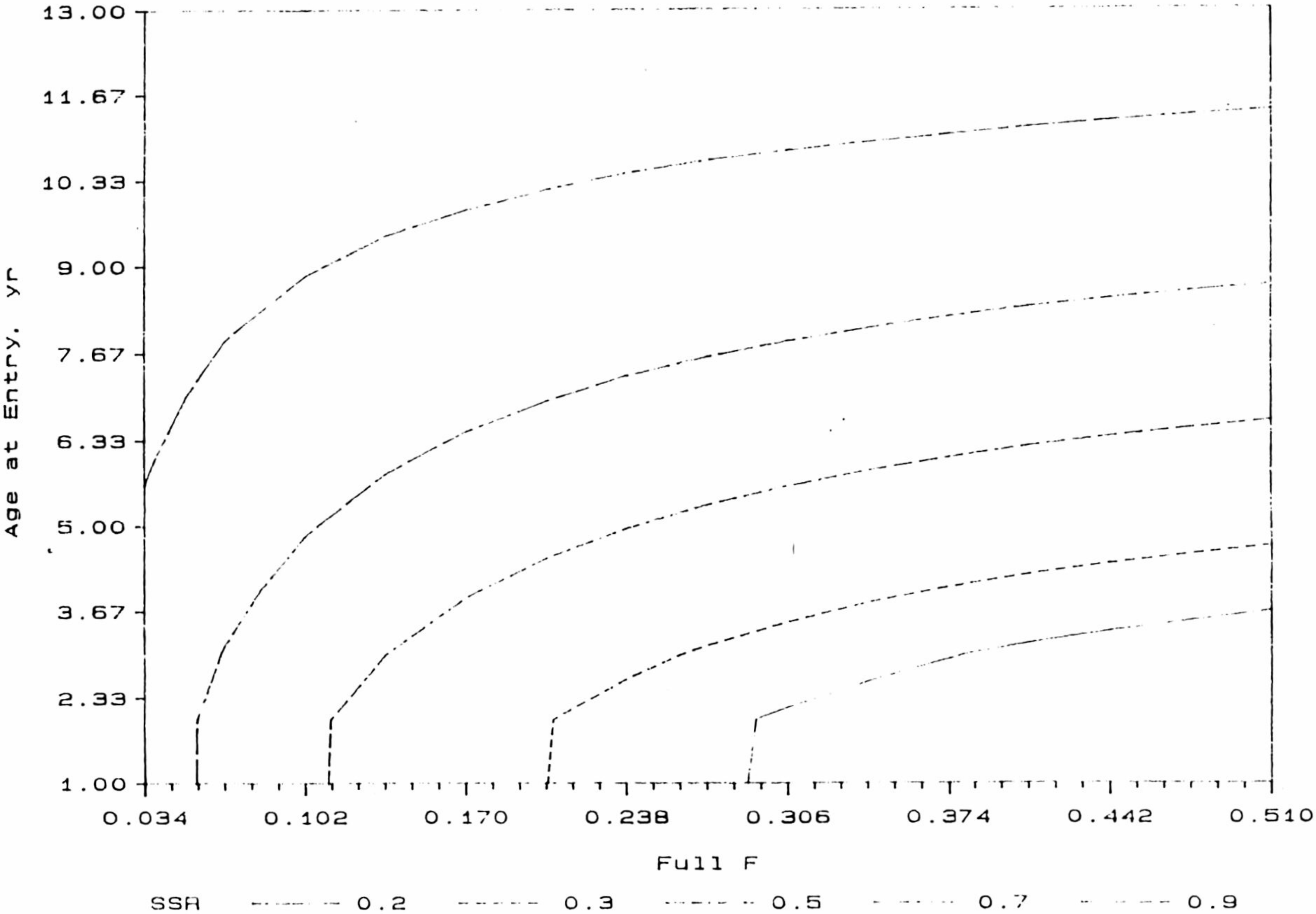


Figure 23

Ricker Yield per Recruit for MUTTON SNAPPER (S ATLANTIC)

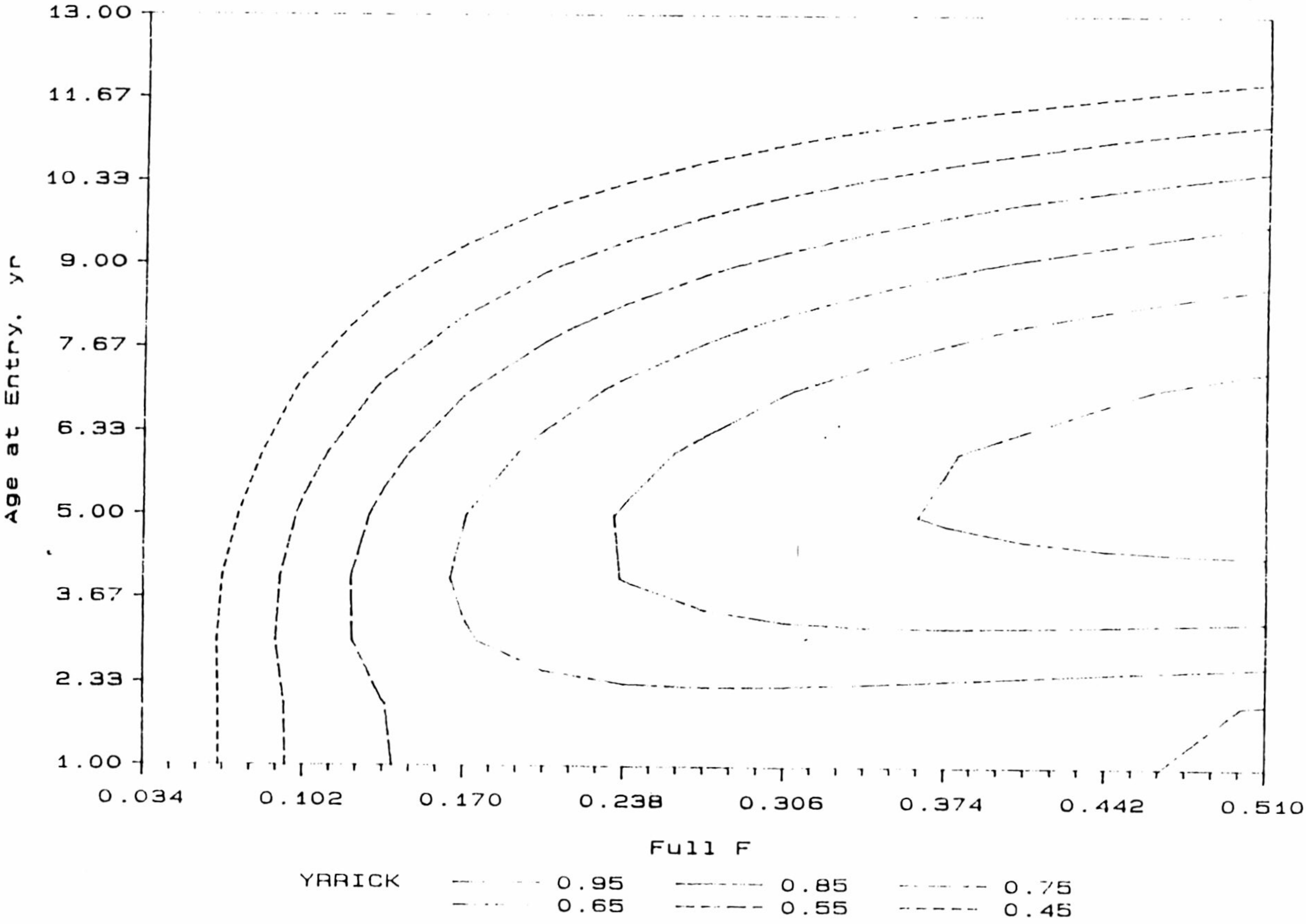


Figure 24

Spawning Stock Ratio for YELLOWTAIL SNAPPER (S ATLANTIC)

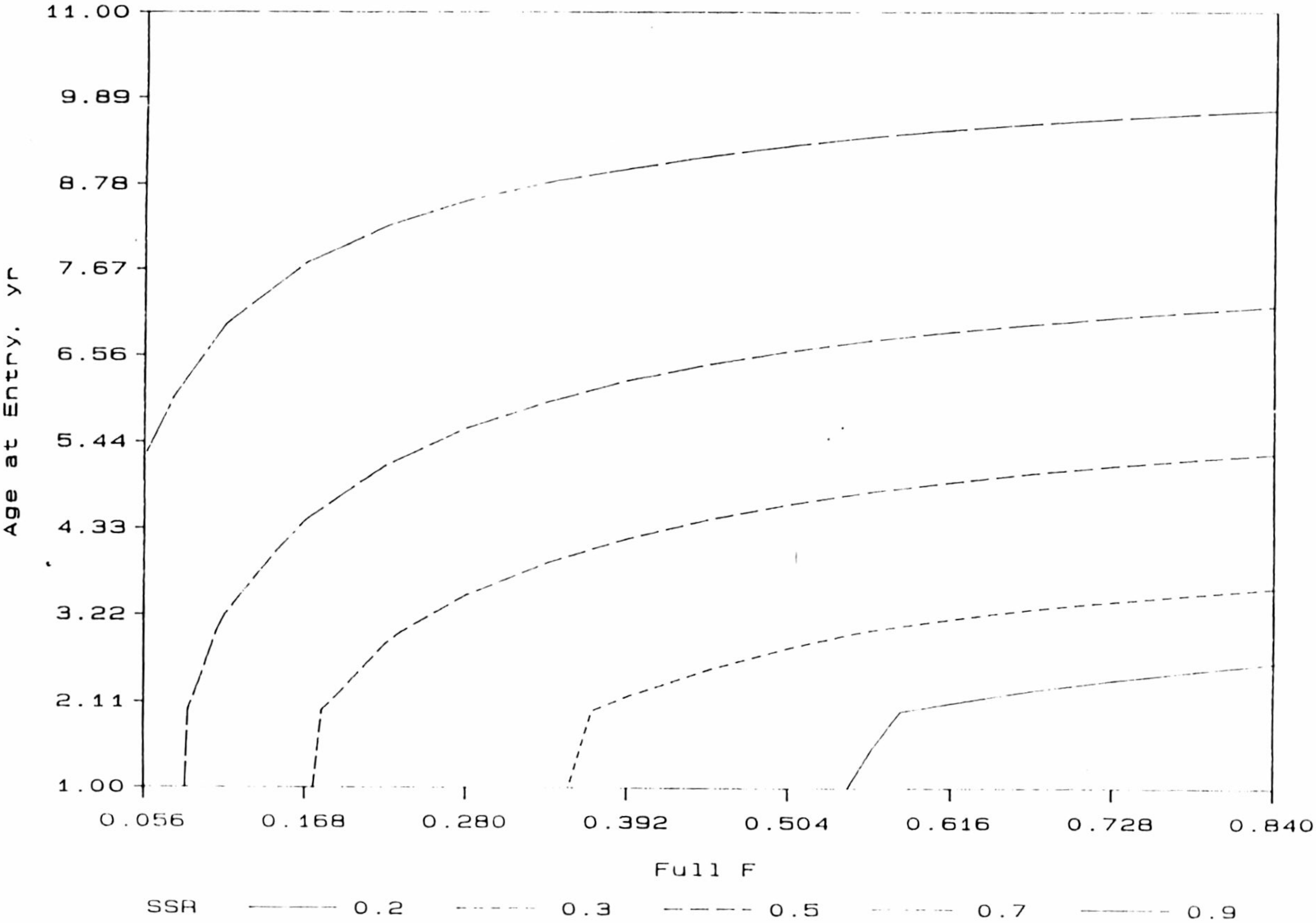


Figure 25

Ricker Yield per Recruit for YELLOWTAIL SNAPPER (S ATLANTIC)

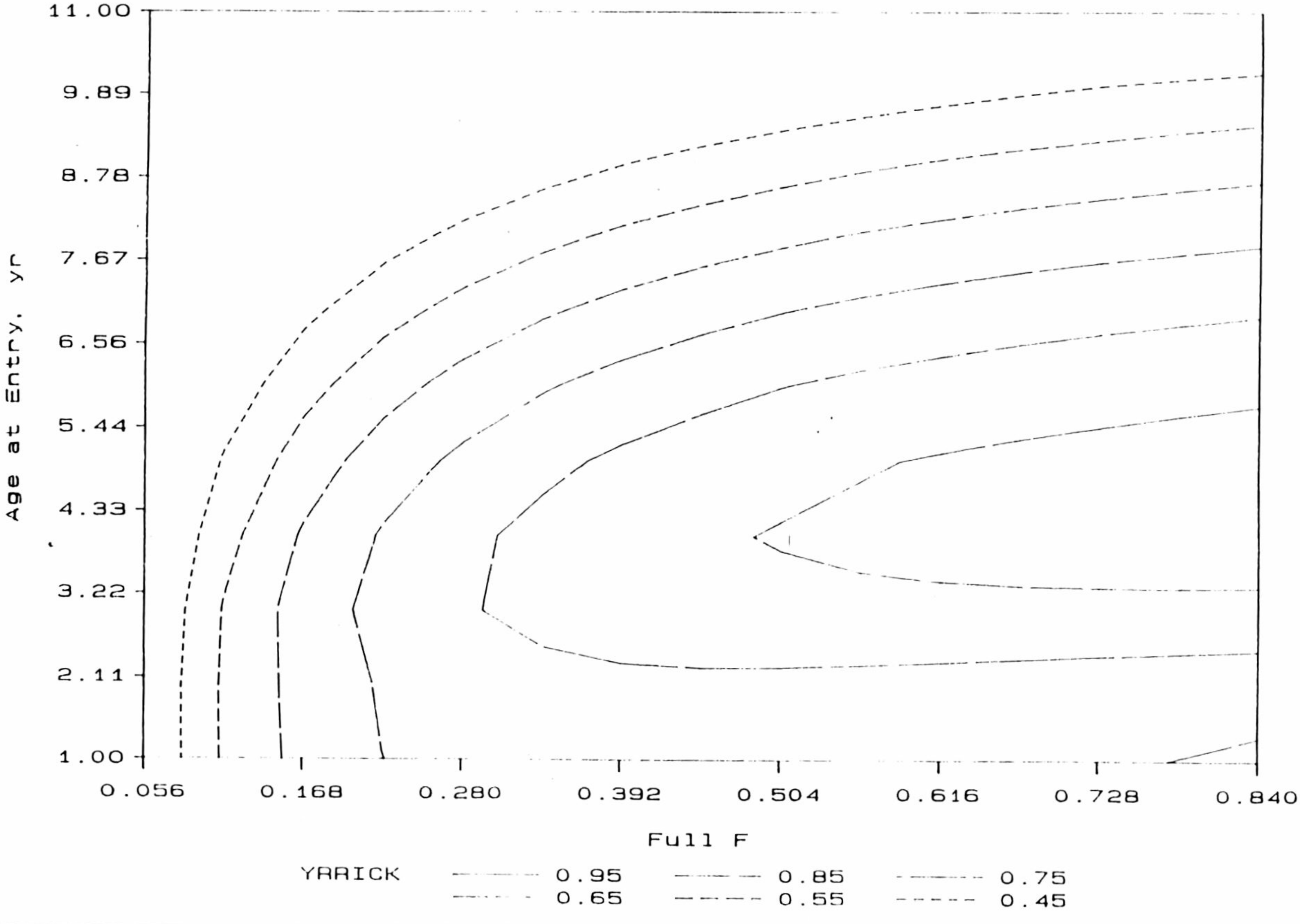
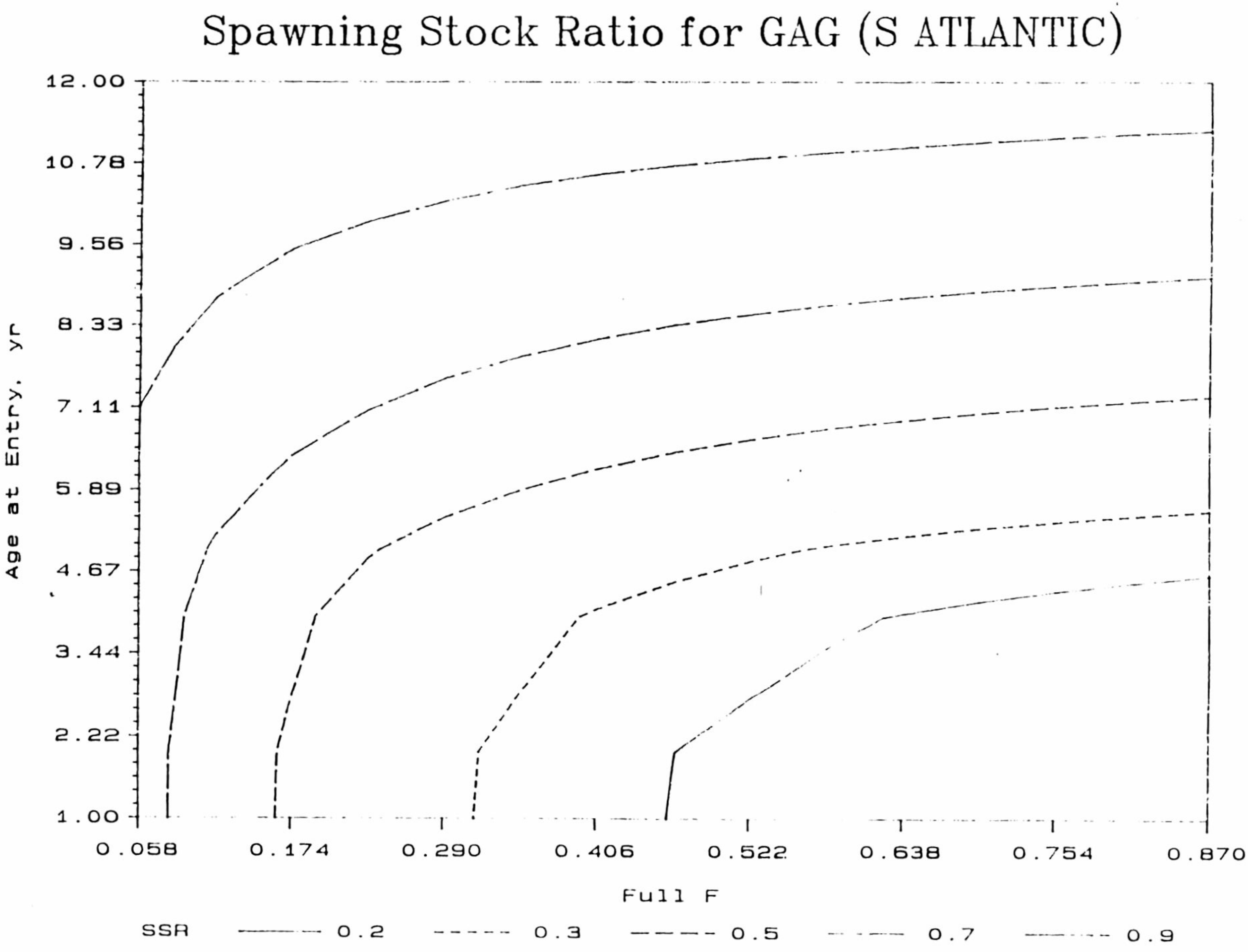


Figure 26


Spawning Stock Ratio for GAG (S ATLANTIC)
12.00
10.78
9.56
8.33
7.11
5.89
4.67
3.44
2.22
1.00
Age at Entry, yr
0.058
0.174
0.290
0.406
0.522
0.638
0.754
0.870
Full F
SSR
0.2
0.3
0.5
0.7
0.9

Ricker Yield per Recruit for GAG (S ATLANTIC)

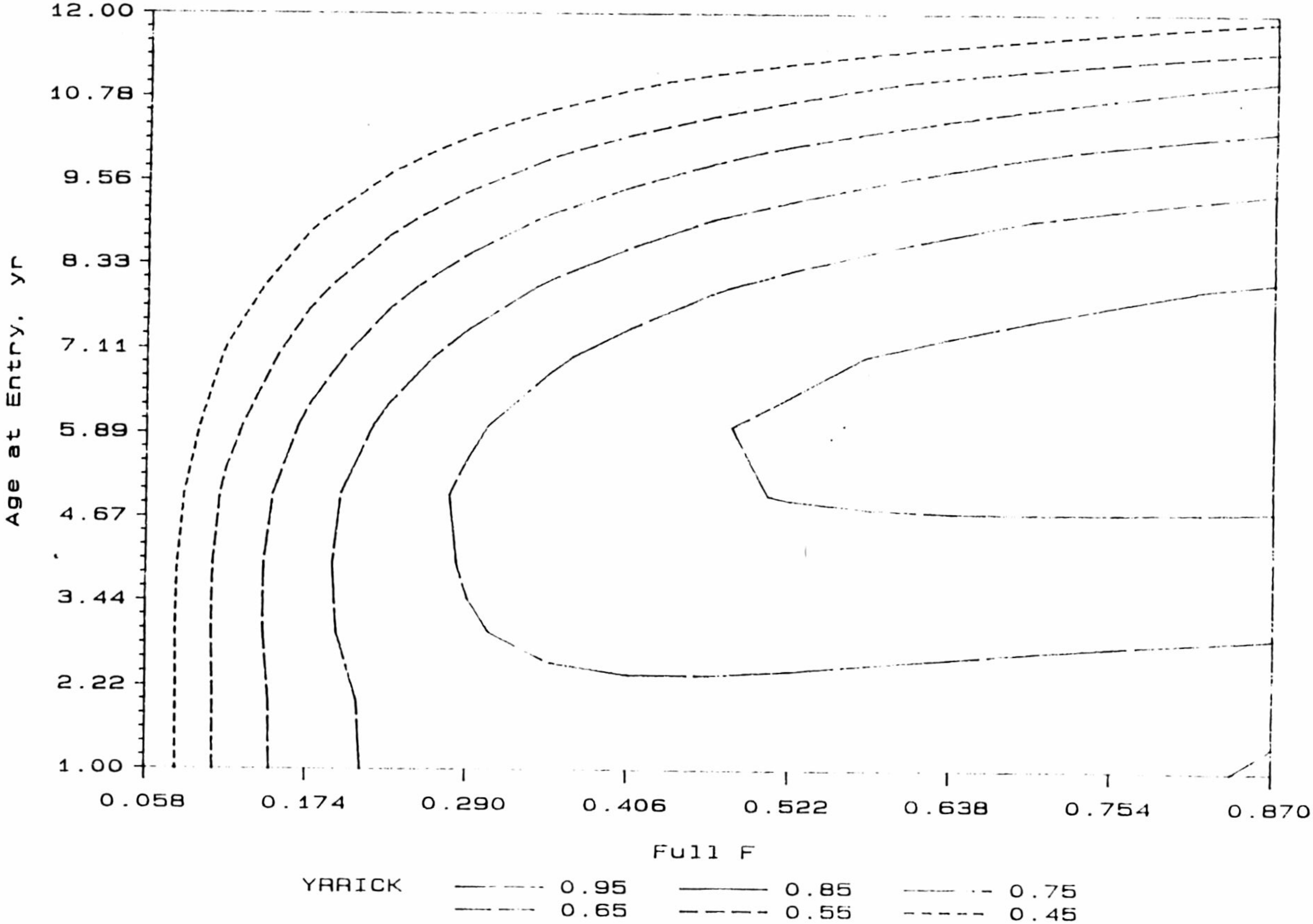


Figure 28

Spawning Stock Ratio for SCAMP (S ATLANTIC)

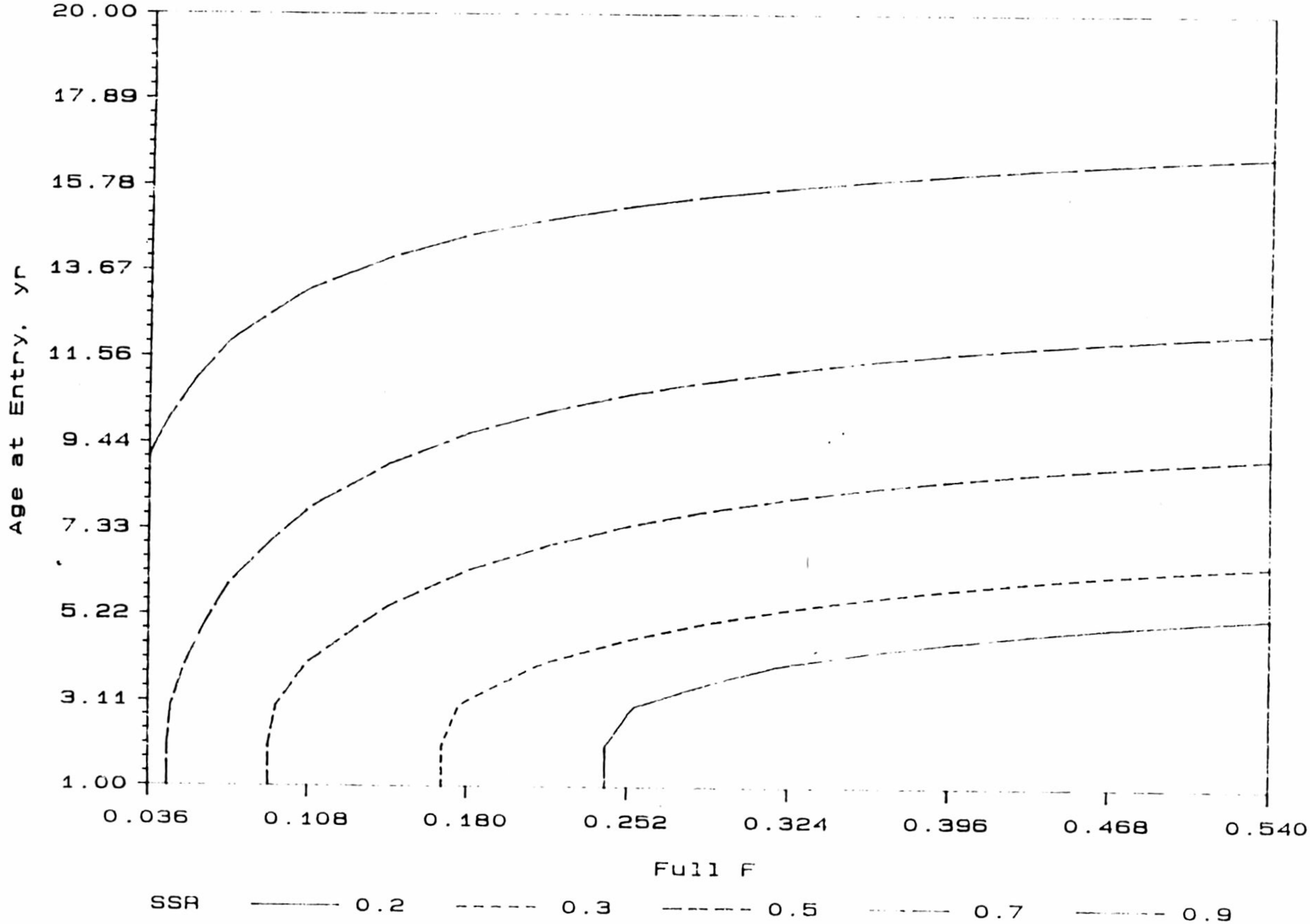


Figure 29

Ricker Yield per Recruit for SCAMP (S ATLANTIC)

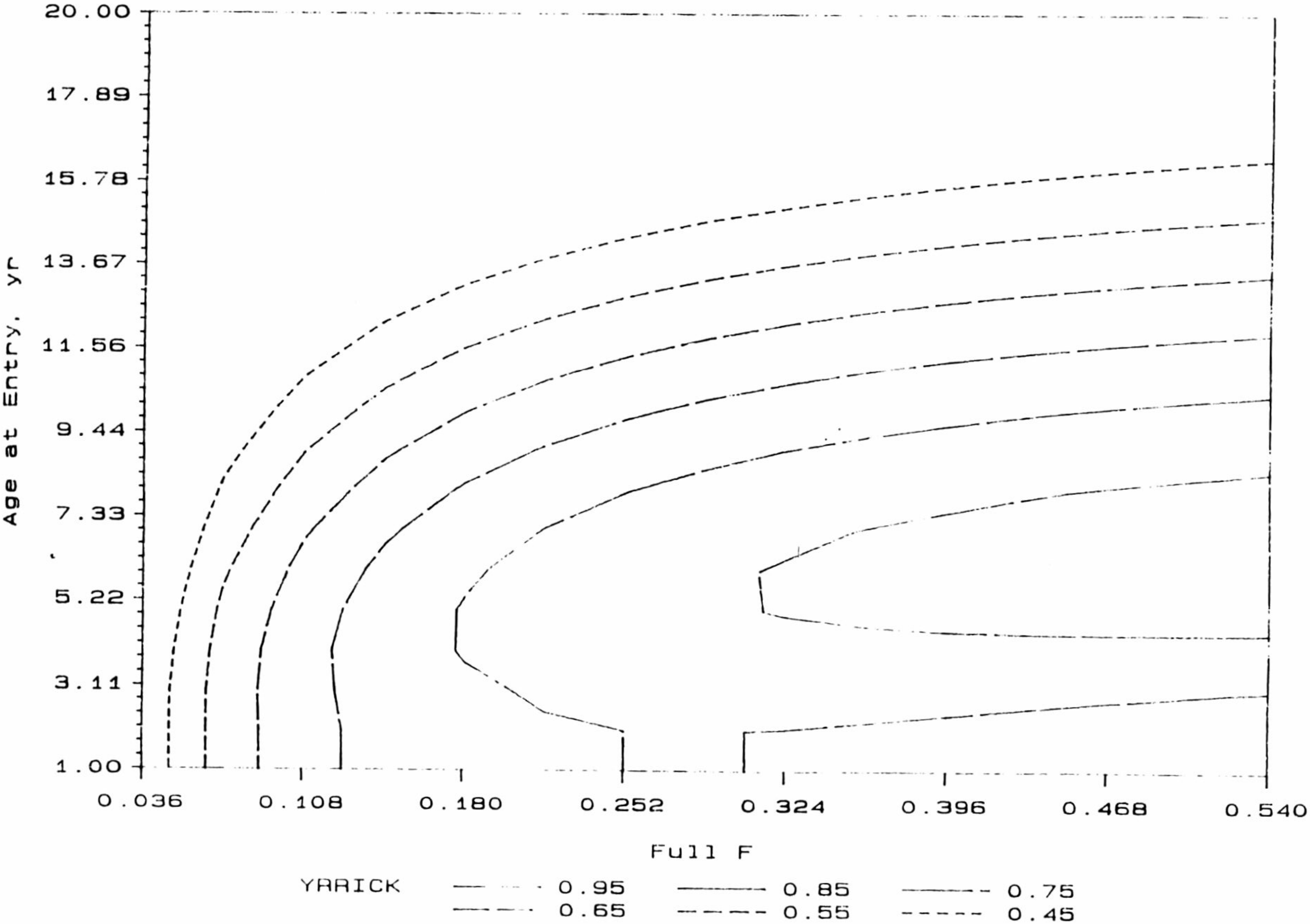


Figure 30

Spawning Stock Ratio for BLACK GROUPER (S ATLANTIC)

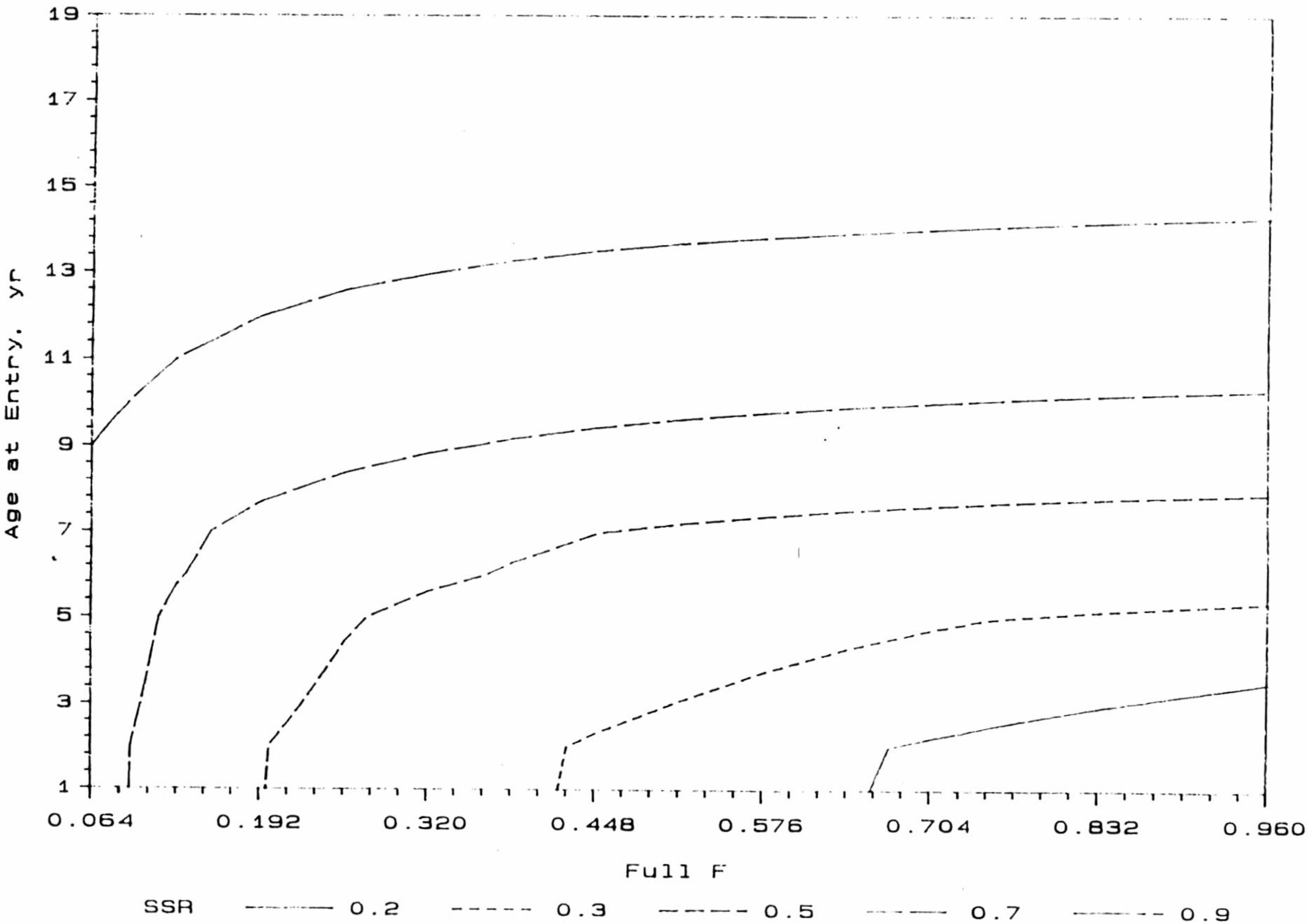


Figure 31

Ricker Yield per Recruit for BLACK GROUPER (S ATLANTIC)

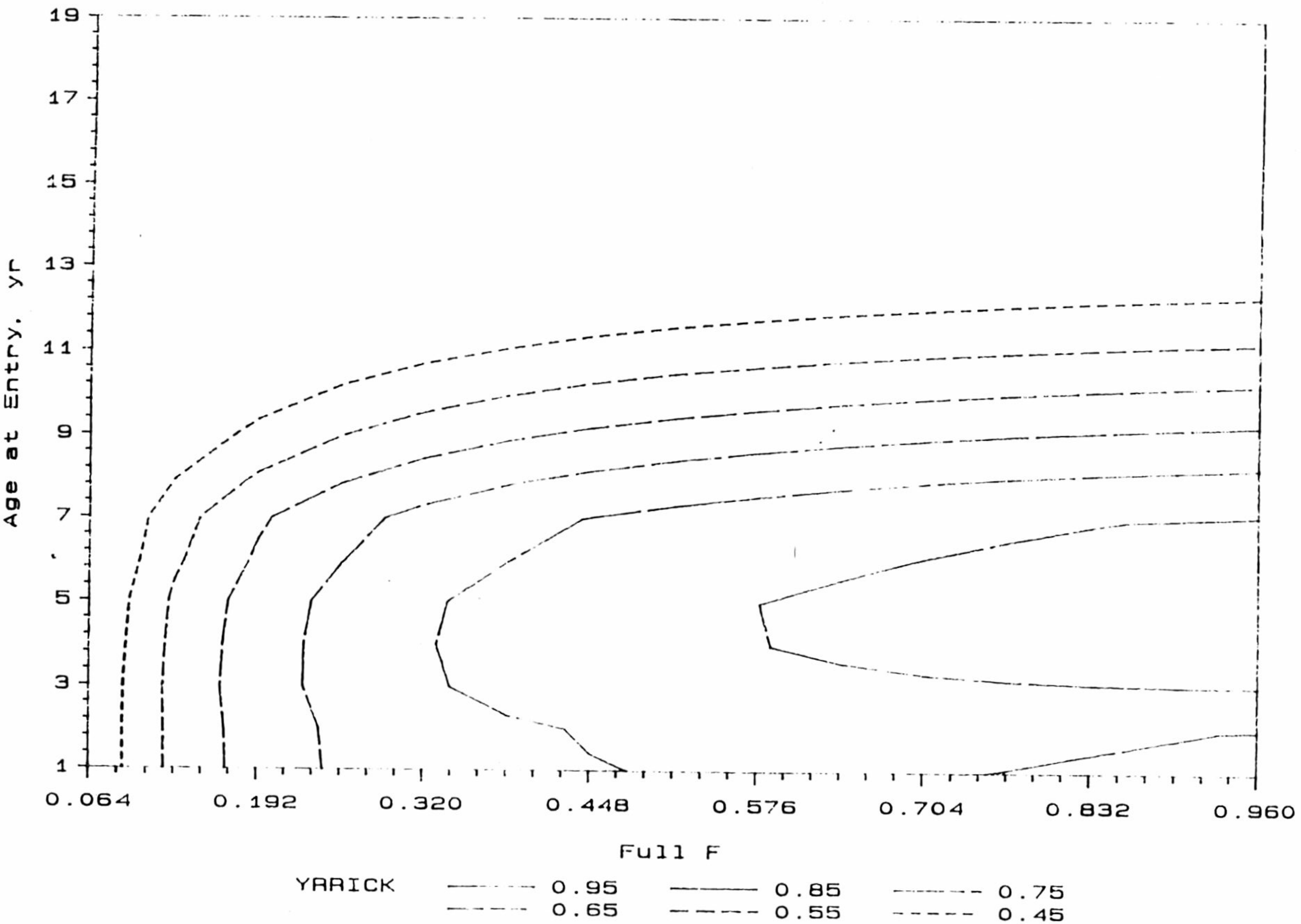


Figure 32

Spawning Stock Ratio for SPECKLED HIND (S ATLANTIC)

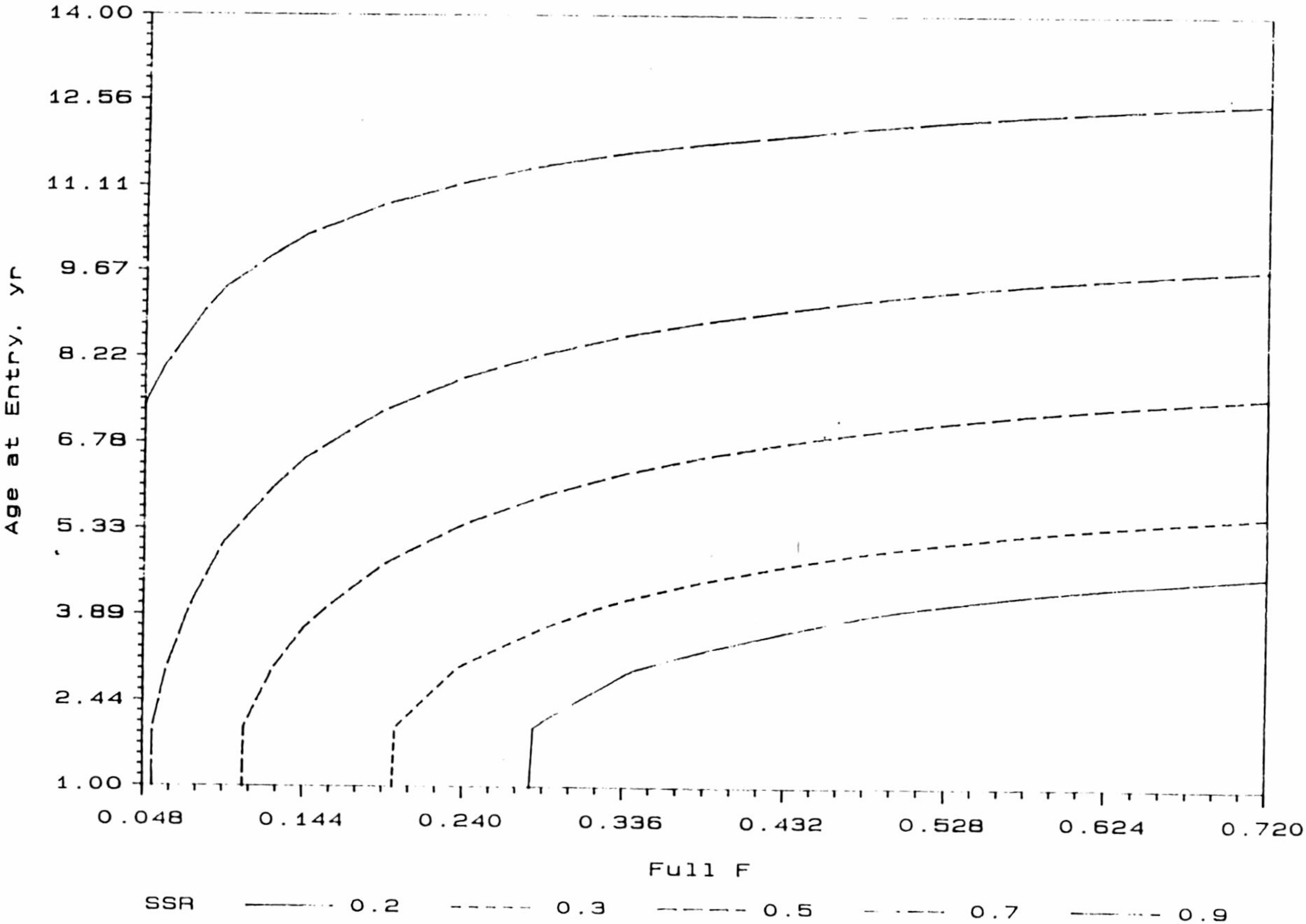


Figure 33

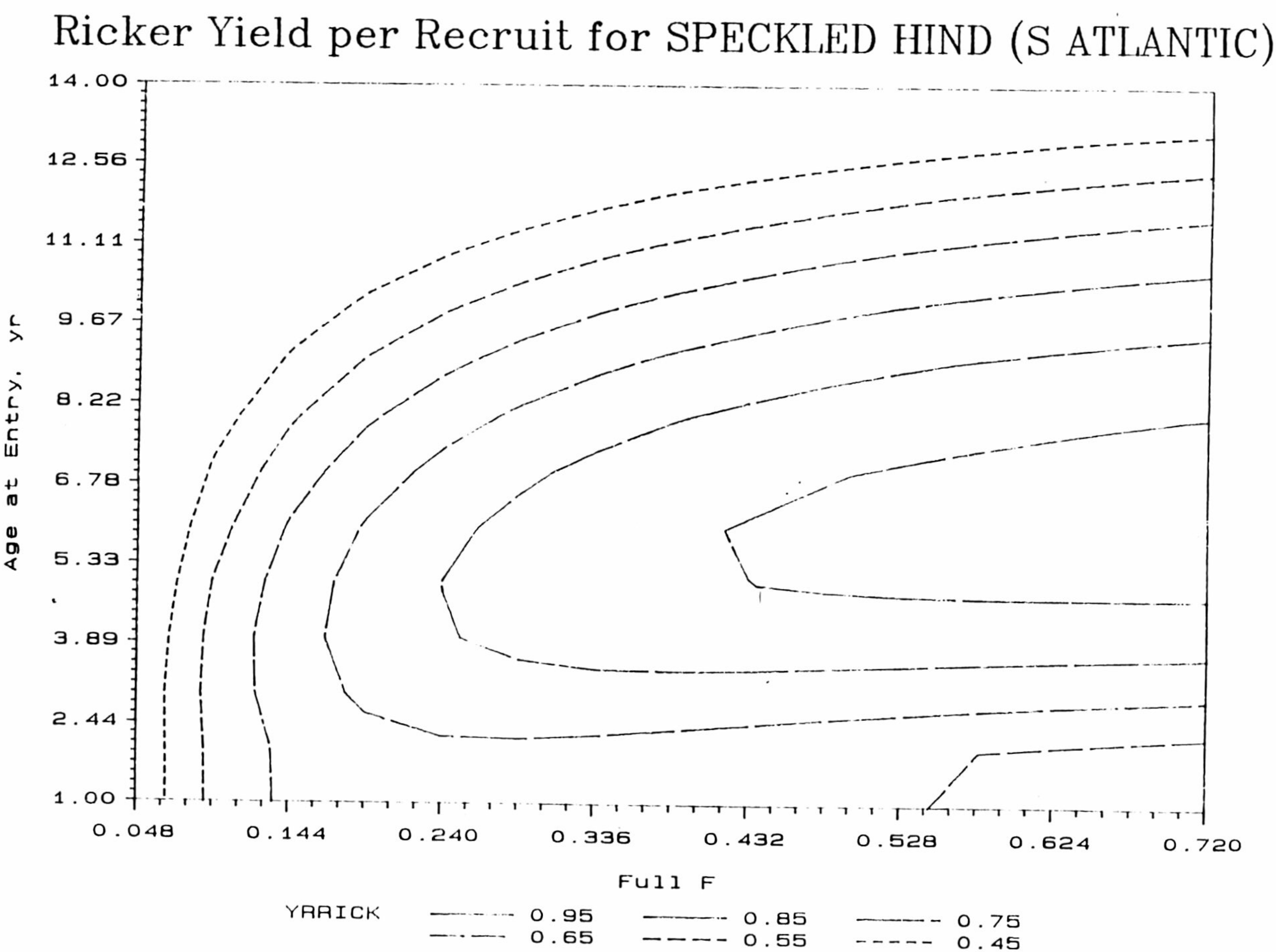

Ricker Yield per Recruit for SPECKLED HIND (S ATLANTIC)
14.00
12.56
11.11
9.67
8.22
6.78
5.33
3.89
2.44
1.00
Age at Entry, yr
0.048
0.144
0.240
0.336
0.432
0.528
0.624
0.720
Full F
YRRICK
0.95
0.85
0.75
0.65
0.55
0.45

Figure 34

Spawning Stock Ratio for WARSAW GROUPER (S ATLANTIC)

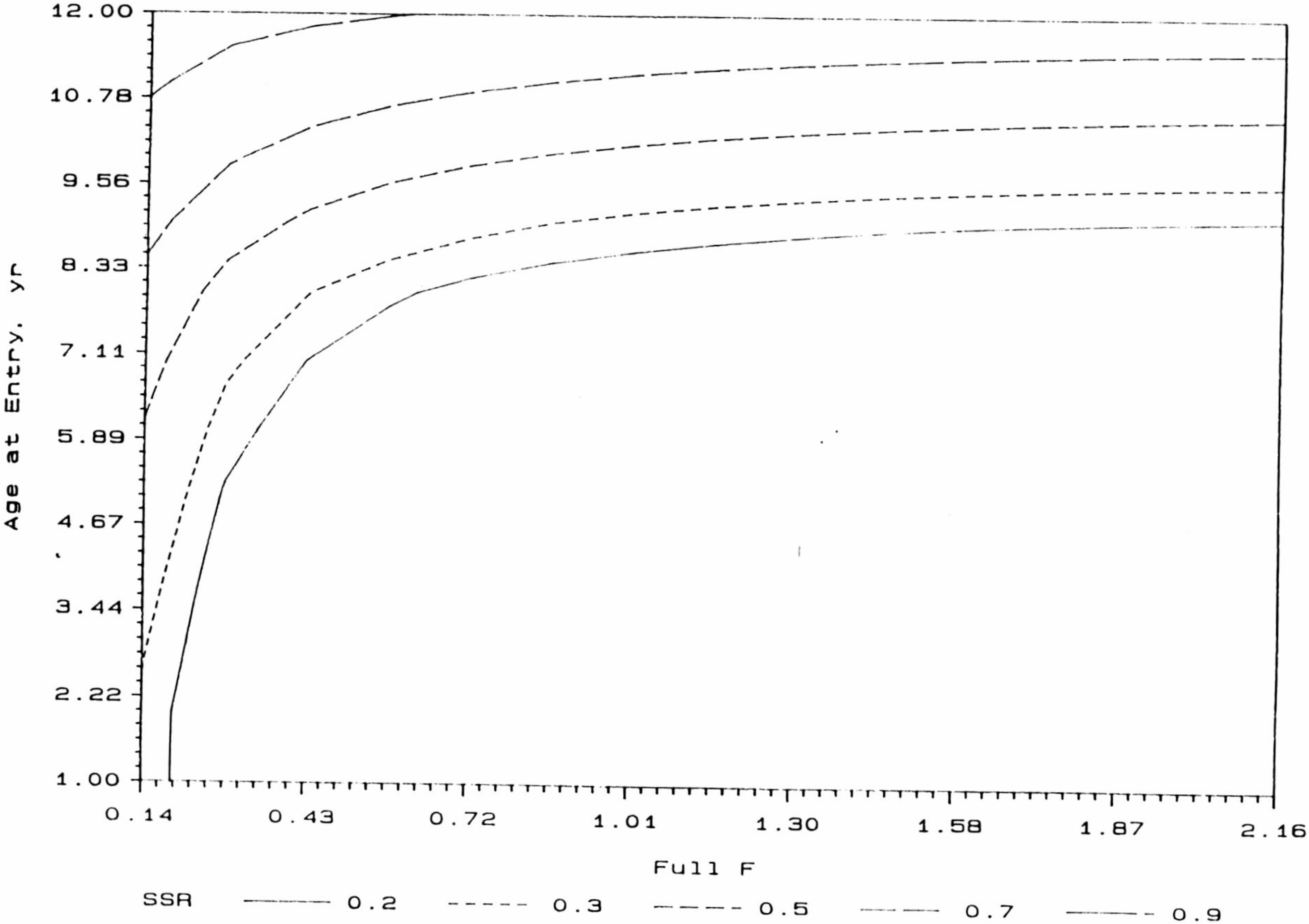
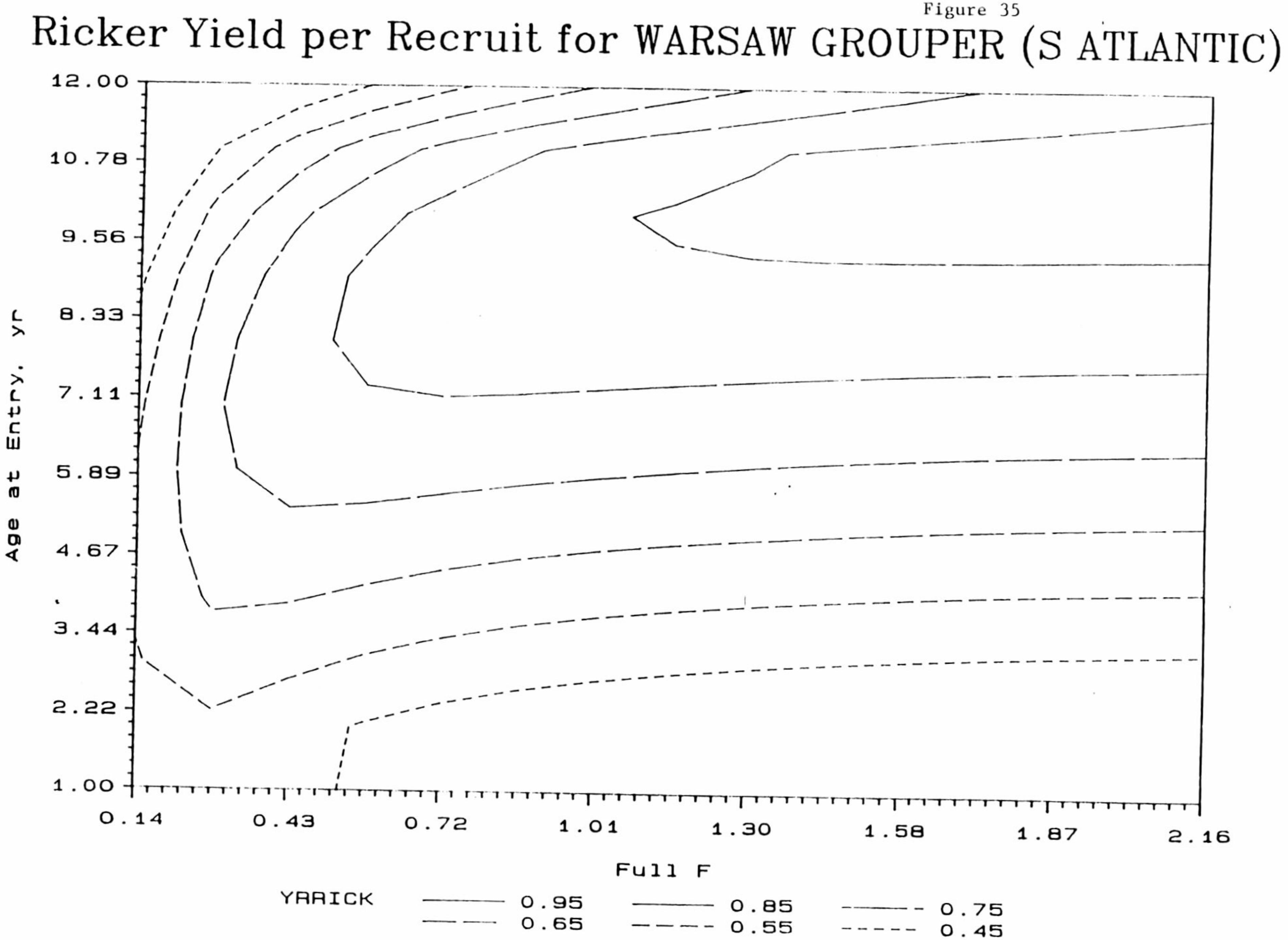


Figure 35



Ricker Yield per Recruit for WARSAW GROUPER (S ATLANTIC)
12.00
10.78
9.56
8.33
7.11
5.89
4.67
3.44
2.22
1.00
Age at Entry, yr
0.14
0.43
0.72
1.01
1.30
1.58
1.87
2.16
Full F
YRRICK
0.95
0.85
0.75
0.65
0.55
0.45

Spawning Stock Ratio for SNOWY GROUPER (S ATLANTIC)

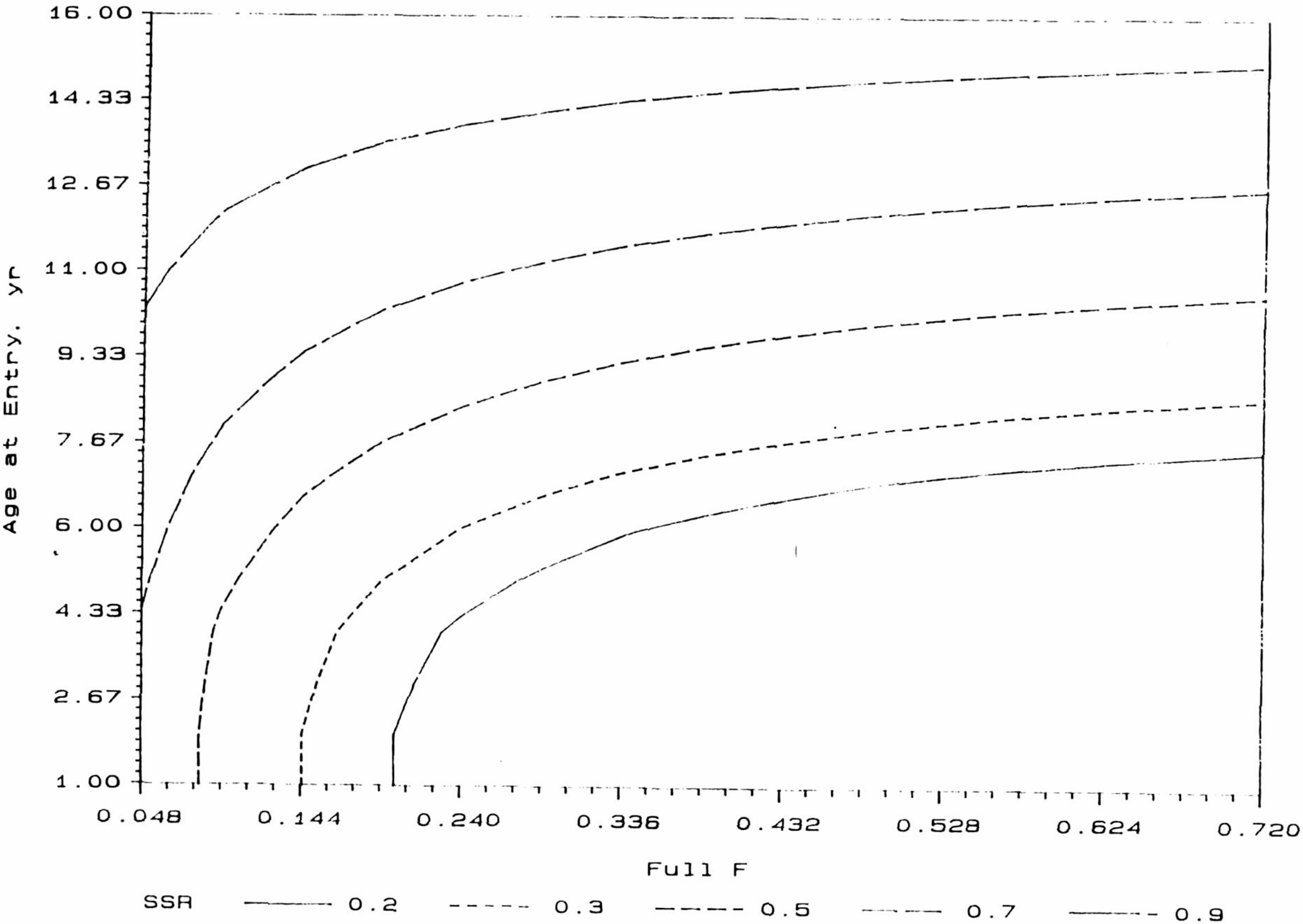
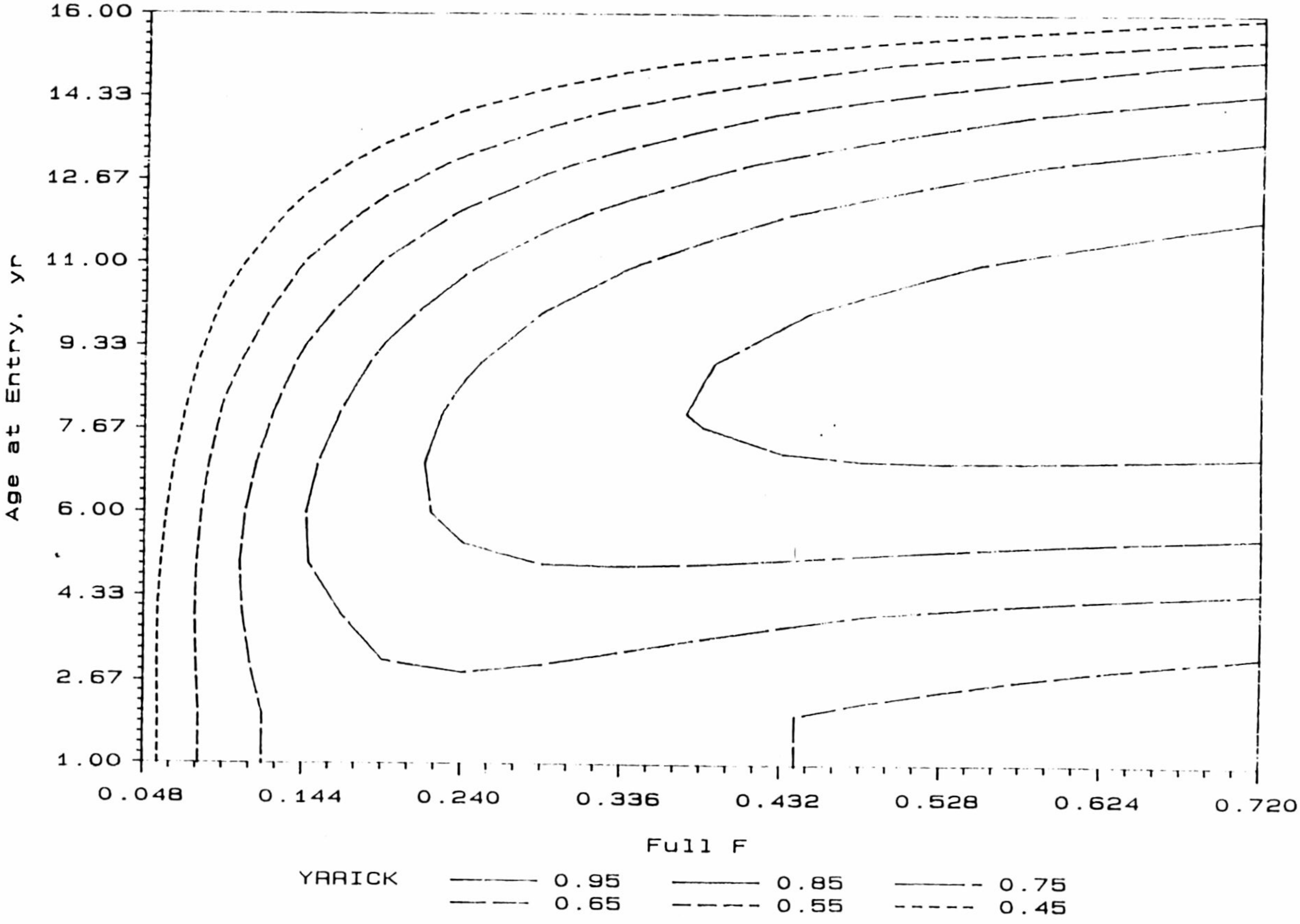


Figure 37

Ricker Yield per Recruit for SNOWY GROUPER (S ATLANTIC)



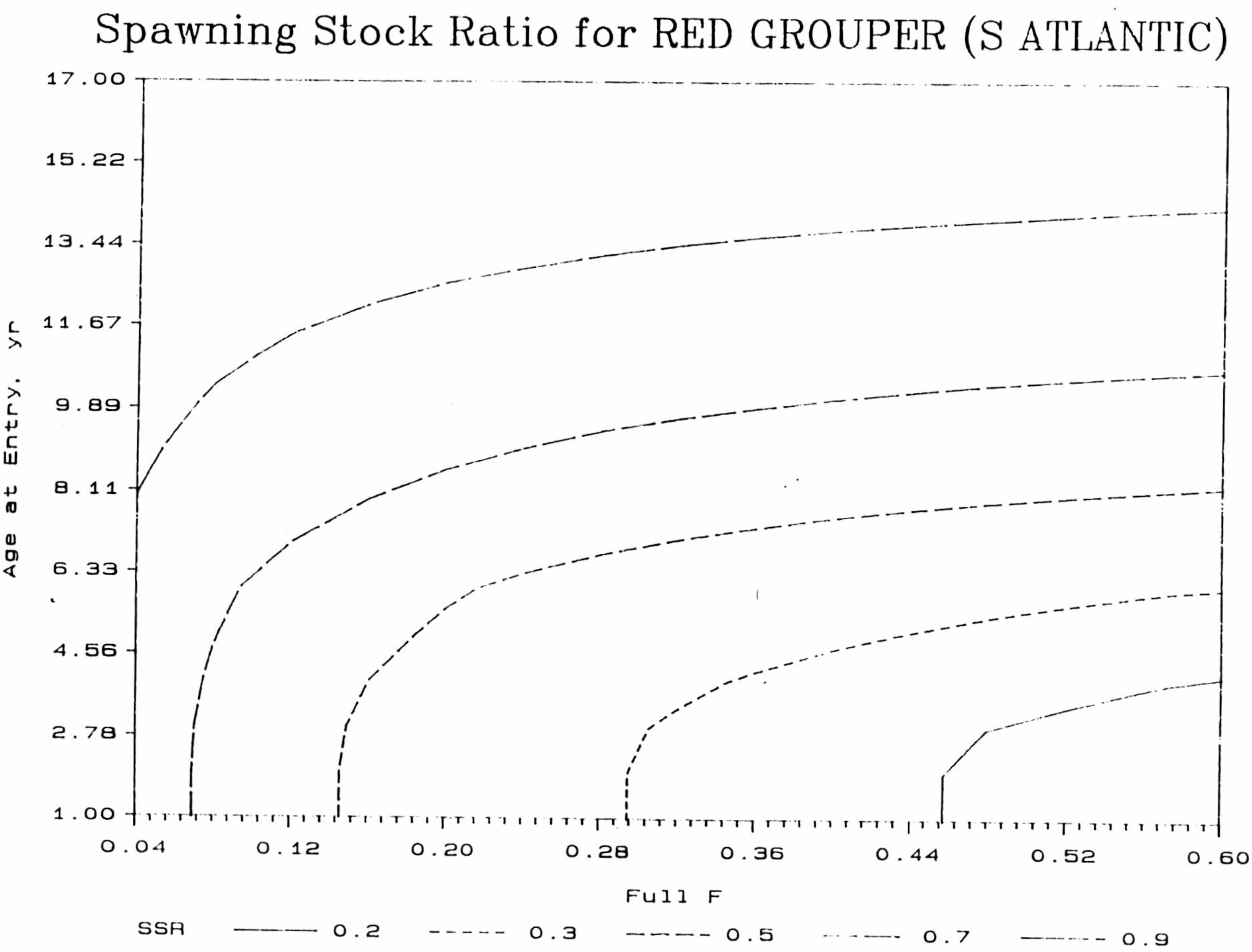
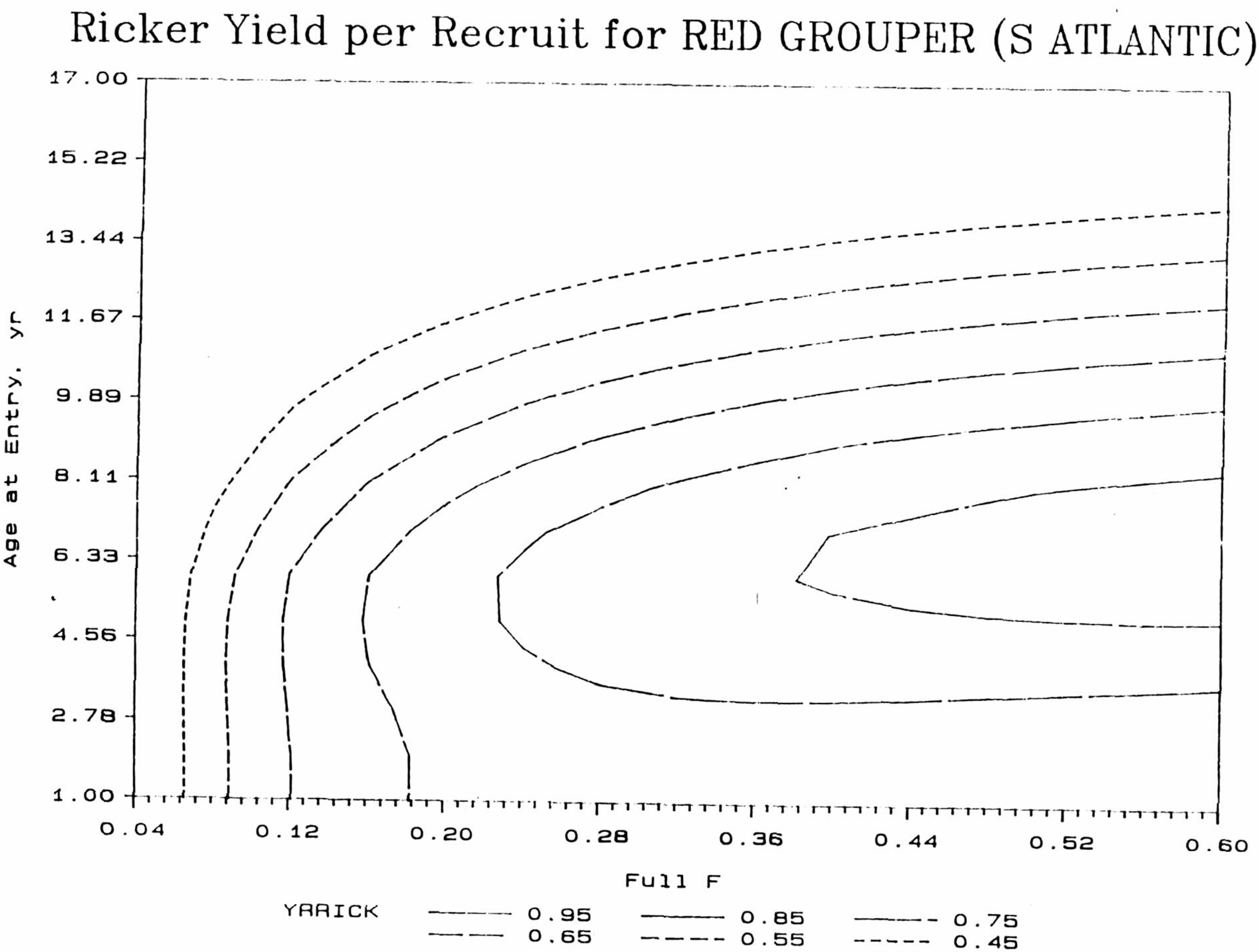

Spawning Stock Ratio for RED GROUPER (S ATLANTIC)
17.00
15.22
13.44
11.67
9.89
8.11
6.33
4.56
2.78
1.00
Age at Entry, yr
0.04
0.12
0.20
0.28
0.36
0.44
0.52
0.60
Full F
SSR
0.2
0.3
0.5
0.7
0.9

Figure 39


Ricker Yield per Recruit for RED GROUPER (S ATLANTIC)
17.00
15.22
13.44
11.67
9.89
8.11
6.33
4.56
2.78
1.00
Age at Entry, yr
0.04
0.12
0.20
0.28
0.36
0.44
0.52
0.60
Full F
YRRICK
0.95
0.85
0.75
0.65
0.55
0.45