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On the Criteria (Reference Points) of Biomass, and Approaches to Some Fishery Management in the North Western Atlantic Ocean

By

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Abstract

The pattern of point scatter in the stock-recruitment relationship plots is considered in relation to silver hake in Div. 4VWX, cod in Div. 2J+3KL, Div. 3NO and Subdiv. 3Ps, yellowtail flounder in Div. 3LNO, redfish in Div. 3M and mackerel in Subareas 3-6. The optimal range of spawning biomass was assessed approximately for cod in Div. 3NO, Subdiv. 3Ps, redfish in Div. 3M, yellowtail flounder in Div. 3LNO, mackerel in Subareas 3-6, and no scientific background was found for assessment of only one possible B_{lim} in all cases. The opinion is expressed on a strong and sometimes key impact of environmental factors upon year-class abundance of all above-mentioned populations. A flexible approach to fishery management is proposed on the basis of data on the state of those stocks and dynamics trends.

Introduction

At present titanic efforts are made by the international fishery organizations, primarily by NAFO and ICES, to elaborate a scientific background for the precautionary approach (PA) to be implemented in the fishery. The main attention is paid to definition of reference points (RP), specifying a new strategy of management and to assessment of the latter values by individual fishing objects. While the first part of the problem has been settled rather easily (Serchuk *et al*., MS 1997), the second one has created significant difficulties at least in NAFO Area. The attempts to estimate RP values for the bulk of commercial populations failed. It seems that in such situations, some other more flexible criteria and approaches to fishery management should be looked for. The article presented here shows the results of such attempts.

Materials and Methods

The data on spawning stock biomass (abundance) (SSB, SSN) and recruitment of silver hake in Div. 4VWX, cod in Div. 2J+3KL, Div. 3NO and Subdiv. 3Ps, yellowtail flounder in Div. 3LNO, redfish in Div. 3M and mackerel in Subareas 3-6 were taken from Clay and Beanlands (MS 1980), Showell (MS 1997), Baird and Bishop (MS 1986), Bishop *et al*. (MS 1990), Anon. (MS 1988), Brodie (MS 1985), Chekhova *et al*. (MS 1980) and Anderson and Overholtz (MS 1979). The plots of stock-recruitment relationship (SRR) were fitted and actual points scatter was analyzed from the point of view of possibility to estimate B_{lim}, defined as "the level of spawning stock biomass that the stock should not be allowed to fall below" and to propose other approaches to fishery management.

Irrespective of the reliability of absolute biomass and abundance estimates, it was assumed that the latter showed the pattern of the relation considered sufficiently correct.

Results and Discussion

Silver hake in Div. 4VWX

Let us consider the pattern of points scatter in Fig. 1 and 2. The picture obtained looks rather strange, however, it provides a background for some conclusions. Thus, no effects of density relation are found within a very wide range of spawning stock biomass (abundance). Within abundance range 900-3 000 million individuals (Fig. 1) and biomass range 100 000-200 000 tons (Fig. 2) both very strong and very weak year-classes appeared. Besides, sharp fluctuations of the latter values were observed for the same spawning stock size. Comparison of the above-mentioned definition of B_{lim} with the points scatter in figures provides a conclusion that in this case the estimation of some fixed level of B_{lim} is hardly possible. Certainly, the lowest observed biomass value may be conditionally assumed as B_{lim} without any references to scientific substantiation of such approach. However, it is rather doubtful that such management strategy will be efficient, taking into account complex pattern of this relation. It seems also problematic to estimate some target (optimum) level of SSB on the basis of the assumption that the latter should provide the maximum probability of annual occurrence of sufficiently abundant recruitment.

The results of research carried out earlier (Rikhter, MS 1998a) supposed a recurrence in silver hake stock dynamics stipulated by appropriate climatic variability, primarily by water temperature fluctuations in the area of its distribution. The author proposed a general approach to silver hake management, based on the exploitation rate regulation by the cycle phases (periods of the abundance increase and decrease).

Cod in Div. 2J+3KL

The pattern of SRR in Fig. 3 allows to assume that recruitment increases with biomass increase starting from 450 000 tons. No trends were found below that limit. The decrease, which occurred in 1970-77, was replaced with the period of increase in late-1970s to early-1980s. In this case like in the previous one, it is difficult to recommend any fixed B_{lim} value. The same may be said about the target level of SSB. Based on the points scatter and shape of the fitted plot of SRR (Rikhter, MS 1990) we may suppose that probability of strong year-classes occurrence increases with the spawning biomass increase.

Cod in Div. 3NO

In Fig. 4 it is apparent that the group of strong and average year-classes appeared in the range of SSB 90 000-150 000 tons, and at both sides of which no signs of good recruitment are observed. Thus, in this case it seems possible to estimate the optimal SSB within the limits mentioned above, which allows to propose management strategy aimed at exploitation rate regulation if biomass deviates from the optimal limits towards either side. In one case the increase of fishing mortality will be required, while in other cases the latter should be reduced right up to total fishery cessation if a dangerous situation occurs.

Cod in Subdiv. 3Ps

Point scatter in Fig. 5 seems to be of a chaotic pattern. Indeed within the range of about 40 000-100 000 tons the ratio of SSB and recruitment seems to totally determined by environmental factors impact. The effect of density relation is likely to appear only at biomass levels outside the limits specified. As in previous cases it is hardly possible to recommend any definite B_{lim} value. Probability of strong (weak) year-classes occurrence seems approximately similar at any biomass value within the above-mentioned limits.

Judging from the pattern of SSR fitted curve (Rikhter, MS 1990), the optimal range of biomass is about 80 000-100 000 tons. However, it seems that the actual points scatter is the more real basis for fishery management strategy development for particular stock unit than any theoretical considerations. In this case fishery regulation probably should not significantly differ from that of Div. 3NO cod.

Yellowtail flounder in Div. 3LNO

On the basis of points scatter, some optimum may be traced in Fig. 6. In any case strong year-classes of yellowtail flounder during the period considered appeared only within the range of SSR 7 000-14 000 tons. The above is confirmed also by the shape of SSR curve (Rikhter, MS 1990), which allows to determine the optimum required approximately within 14 000-17 000 tons.

It is rather difficult to interpret SRR plot drawn on the basis of Canadian survey data (Walsh *et al*., MS 1998). However, from careful consideration it seems possible to isolate the optimal biomass range. It is possible that availability of SSB range being a target one from the point of fishery management is characteristic of the above stock unit.

Redfish in Div. 3M

The pattern of point scatter in Fig. 7 allows to assume that the optimal range of SSB (about 70 000-90 000 tons) exists for redfish in Div. 3M. Probably it should be remembered that we are not speaking about reliability of the absolute values of data used to draw the plots (see "Materials and Methods"). As regards point scatter, the latter provides no background to estimate B_{lim} level in this case also. As in previous similar situations, redfish fishery strategy in general seems to be the regulation of exploitation rate by means of respective changing fishing mortality if SSB value deviates from the optimal level to either side.

Mackerel in Subareas 3-6

The pattern of SSB shown in Fig. 8 seems simpler as compared to the cases considered above. However, it only seems a simple one. If the point scatter in the left side of the figure (biomass of 400 000-600 000 tons) is the evidence of supposed strong impact of environmental factors upon abundant year-class formation, the point scatter in the right side (biomass of more than 800 000 tons) rather evidences the effect of density dependence. As is seen during the period considered, the recruits abundance at the maximum SSB approaches to that at the minimum SSB value, excluding 1966 and especially 1997 year-classes. The picture in the figure hardly allows to estimate the optimal SSB range unlike the estimated curve (Rikhter, MS 1990) the dome shape of which shows the optimum within the approximate range 1 000 000-1 300 000 tons. Based on the above considerations it can be assumed that to maintain the optimal for reproduction SSB level the fishing mortality rate should be regulated to maintain the biomass within the above said limits. It seems reasonable to recommend the total fishery can only at the lowest observed SSB values (below 600 000 tons) and only in the case when the considerations unfavorable for formation of abundant year-classes are expected during the nearest years.

Conclusion

The results of researches carried out allow approximately estimate the optimal range of SSB in five stock units out of seven considered (cod in Div. 3NO, Subdiv. 3Ps, redfish in Div. 3M, yellowtail flounder in Div. 3LNO, mackerel in Subareas 3-6) and reveal uncertainty of scientifically substantiated estimate of the only possible B_{lim} level. Estimation of the latter, e.g. at level of the lowest biomass observed, will hardly provide the results required and may only discredit the precautionary approach idea.

The patterns of point scatter in all figures evidences a strong and sometimes even decisive impact of environmental factors upon year-class strength of all populations considered in this work. It seems that the regulation of commercial exploitation rate depending of the stock conditions and trend dynamics should be the basis of considered species fishery. This means that the approach to the management should be flexible enough (FA). Thus, for example, fishing mortality rate may be maintained at rather high level even at comparatively low level of the stock if the reliable data are available to show that in the nearest years the favorable conditions will exist for good recruitment. And *vice versa*, if the negative information is available, it may be necessary to take measures to reduce fishing pressure inspite of sufficiently high level of the stock.

Such strategy seems to be more acceptable for fish species with a short life cycle and sharp fluctuations of abundance. In the cases when it could be revealed and, even better, to estimate the range of optimal SSB, the latter value should be maintained as far as possible with appropriate limits by means of exploitation rate regulation. If it is impossible to estimate the optimal value, fishery management for fish species with significant fluctuations of abundance should be provided on the basis of the concept of fishing mortality rate corresponding to the size of the stock fished maintaining a so called optimal level of fishery rate (Rikhter, MS1998b). However, if we take into account the necessity to consider trends in the stock dynamics, considerable deviations from the optimal level may occur towards either side. In general, the above-mentioned strategy of fishery management (FA) assumes inevitability of sharp (however controllable) fluctuations of fishing effort in compliance with variations of considered species abundance (Rikhter, MS1998b). As regards such species as redfish recruitment of which is actually represented by several age groups and thus may be considered relatively constant, it seems that the possibility exists to maintain a stable rate of exploitation at the level keeping optimum size of SSB a long period.

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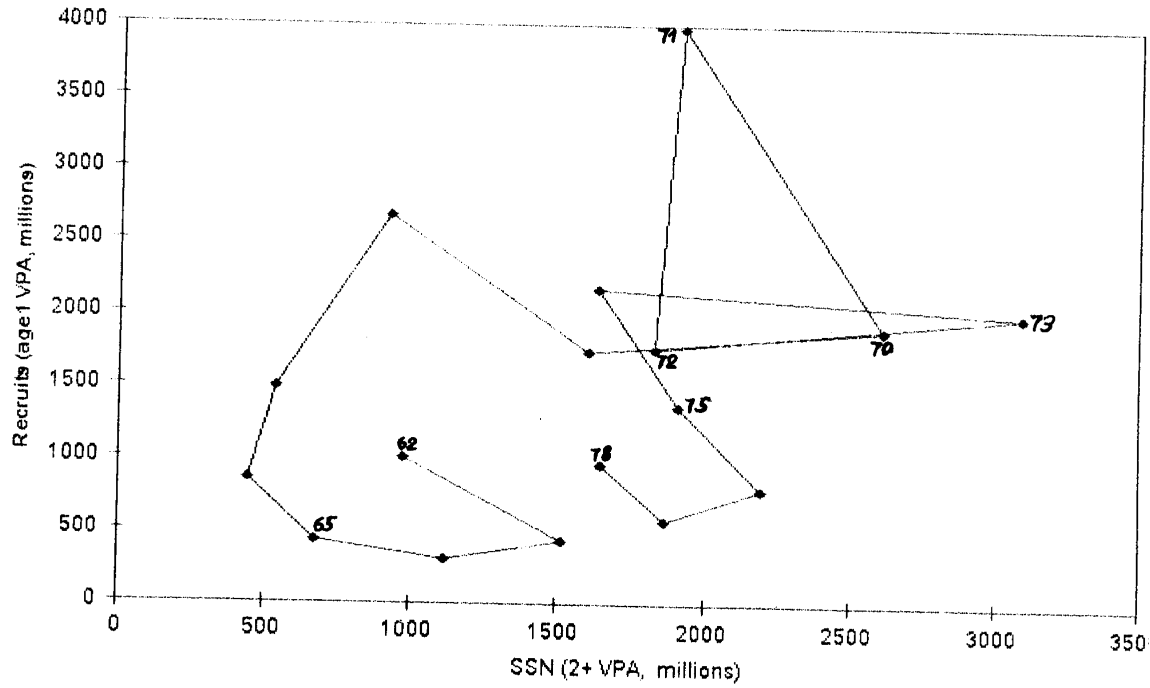

Figure 1. Silver hake in Div. 4VWX: recruits vs SSN scatter plot, 1962-1978.

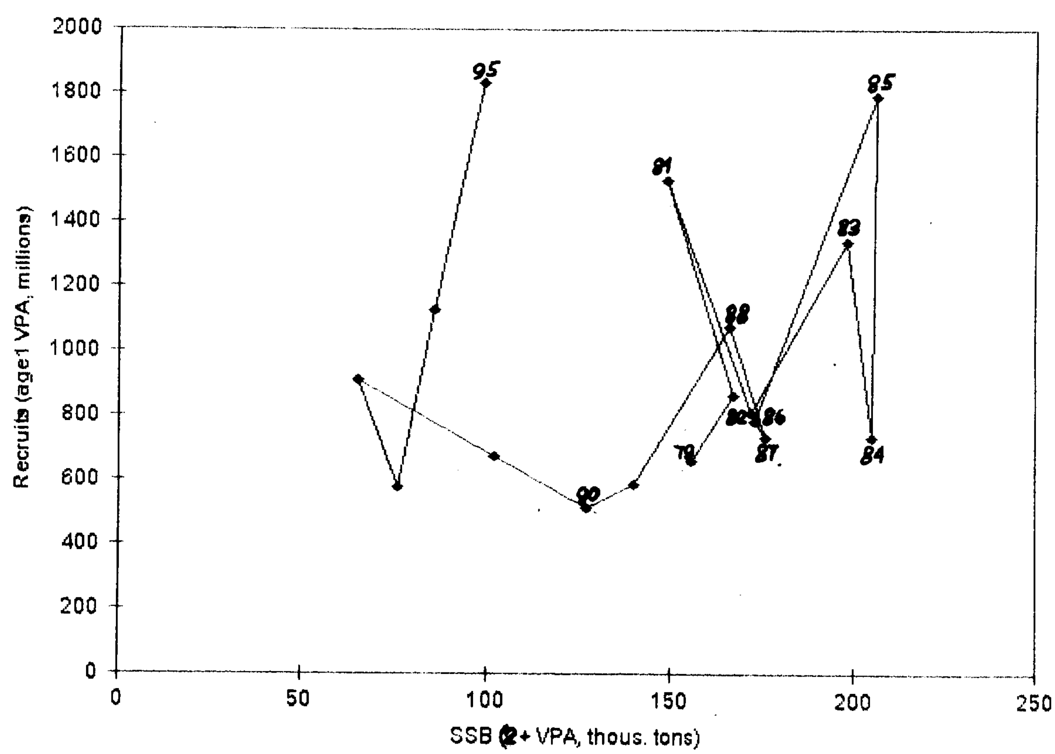

Figure 2. Sliver hake in Div. 4VWX: recruits vs SSB scatter plot, 1979-1995.

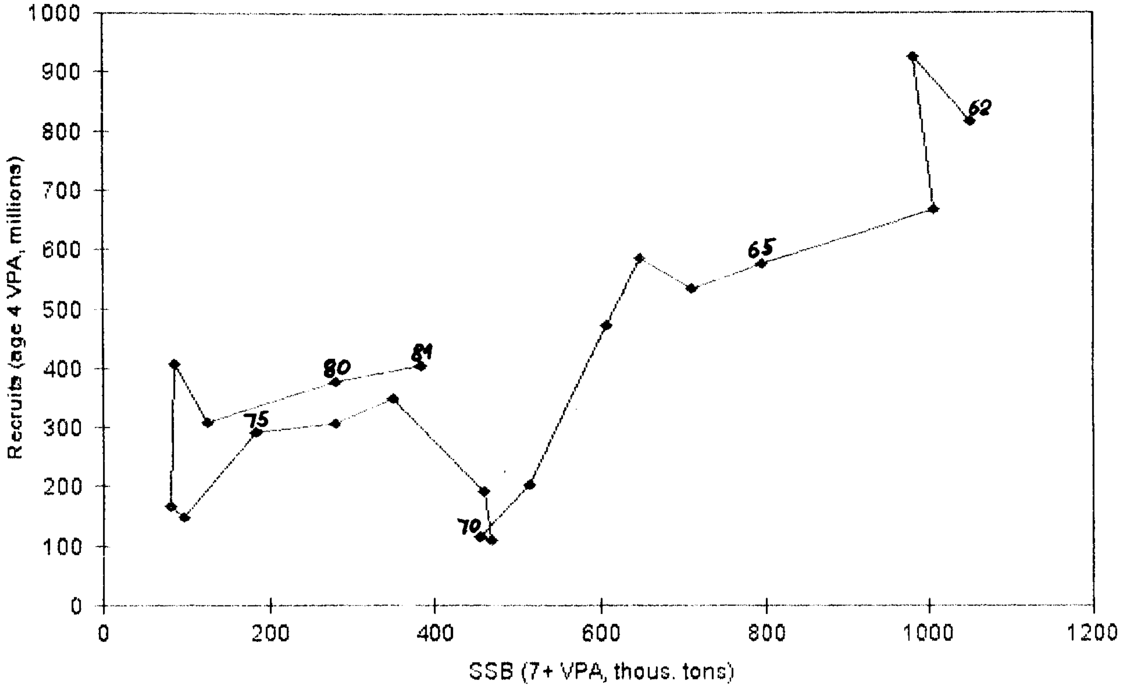

Figure 3. Cod in Div. 2J+3KL: recruits vs SSB scatter plot, 1962-1981.

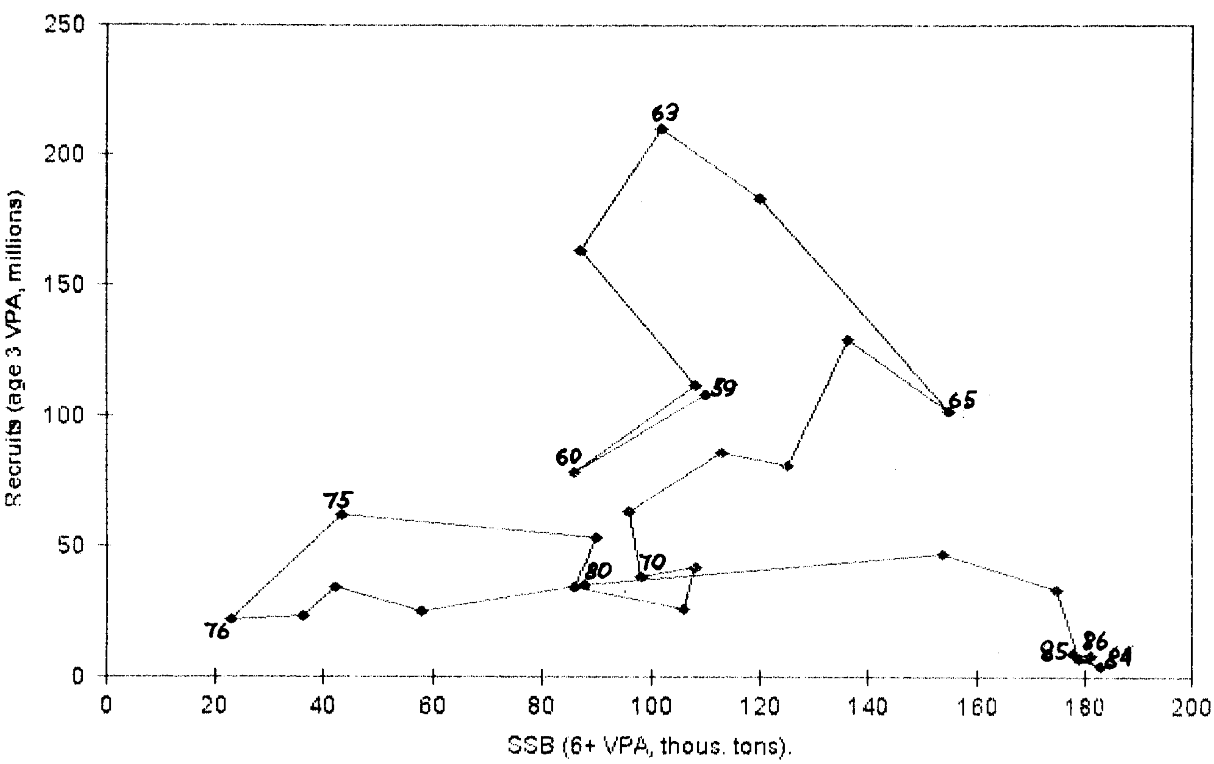

Figure 4. Cod in Div. 3NO: recruits vs SSB scatter plot, 1959-1984.

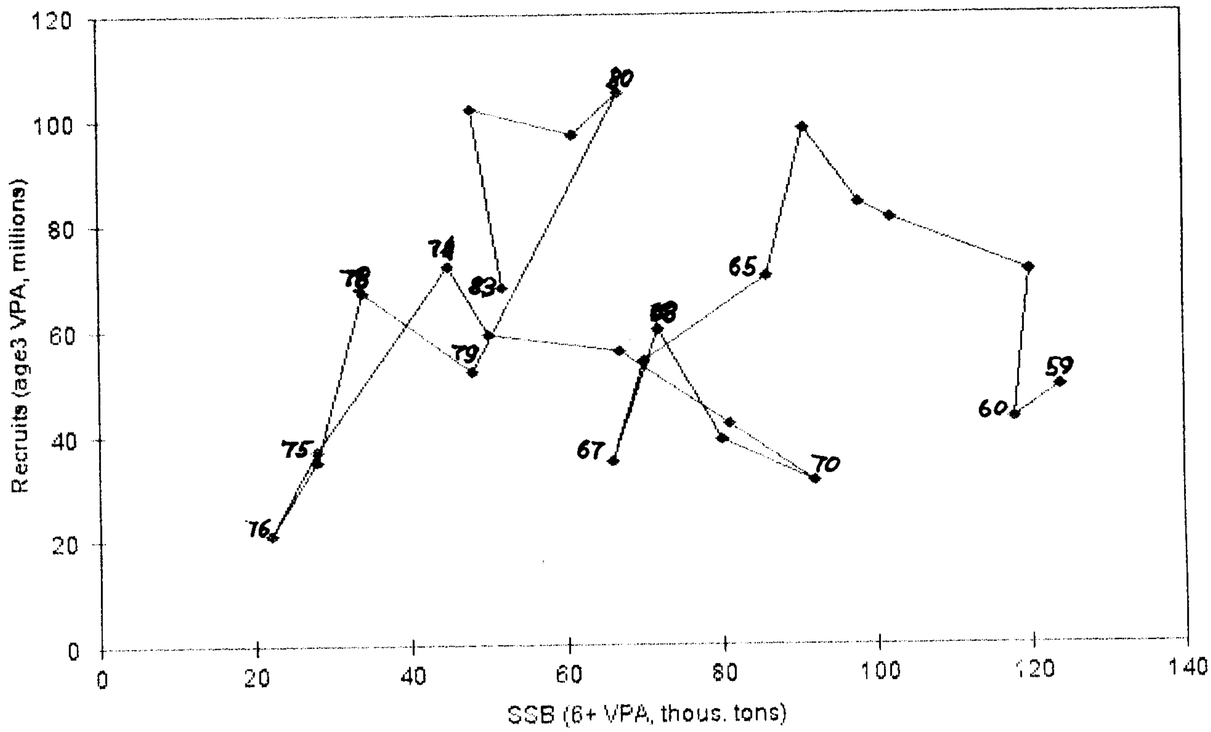

Figure 5. Cod in Subdiv. 3Ps: recruits vs SSB scatter plot, 1968-1980.

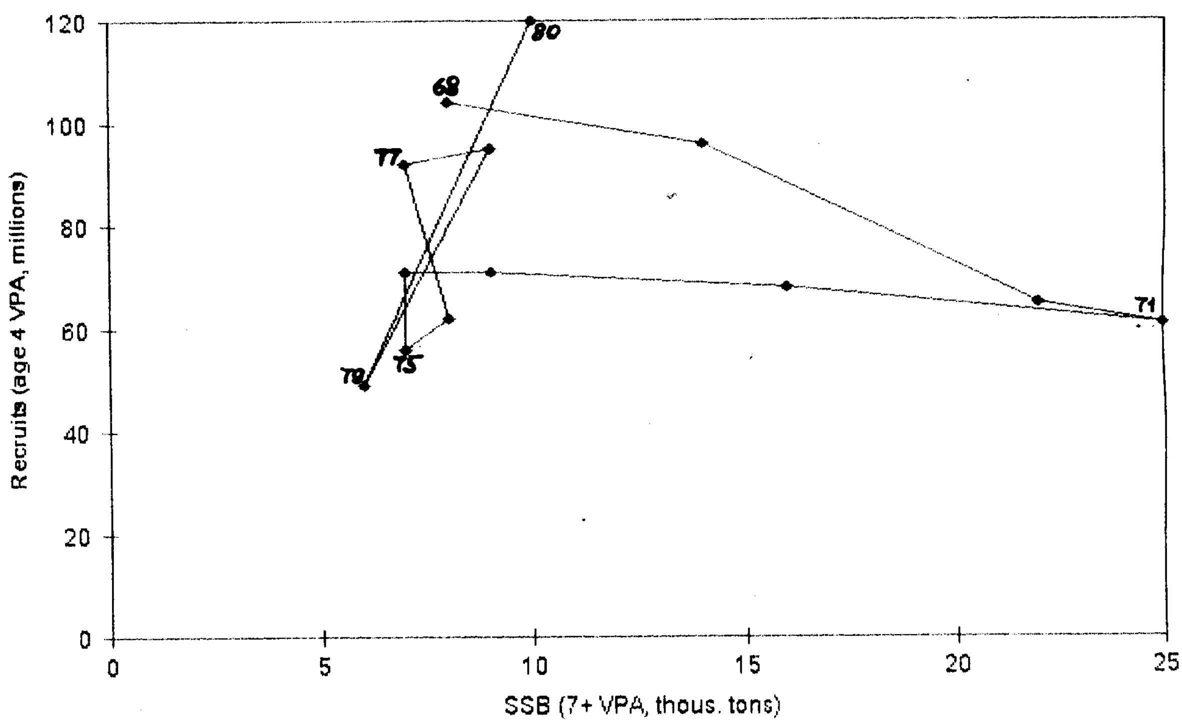

Figure 6. Yellowtail flounder in Div. 3LNO: recruits vs SSB plot, 1968-1980.

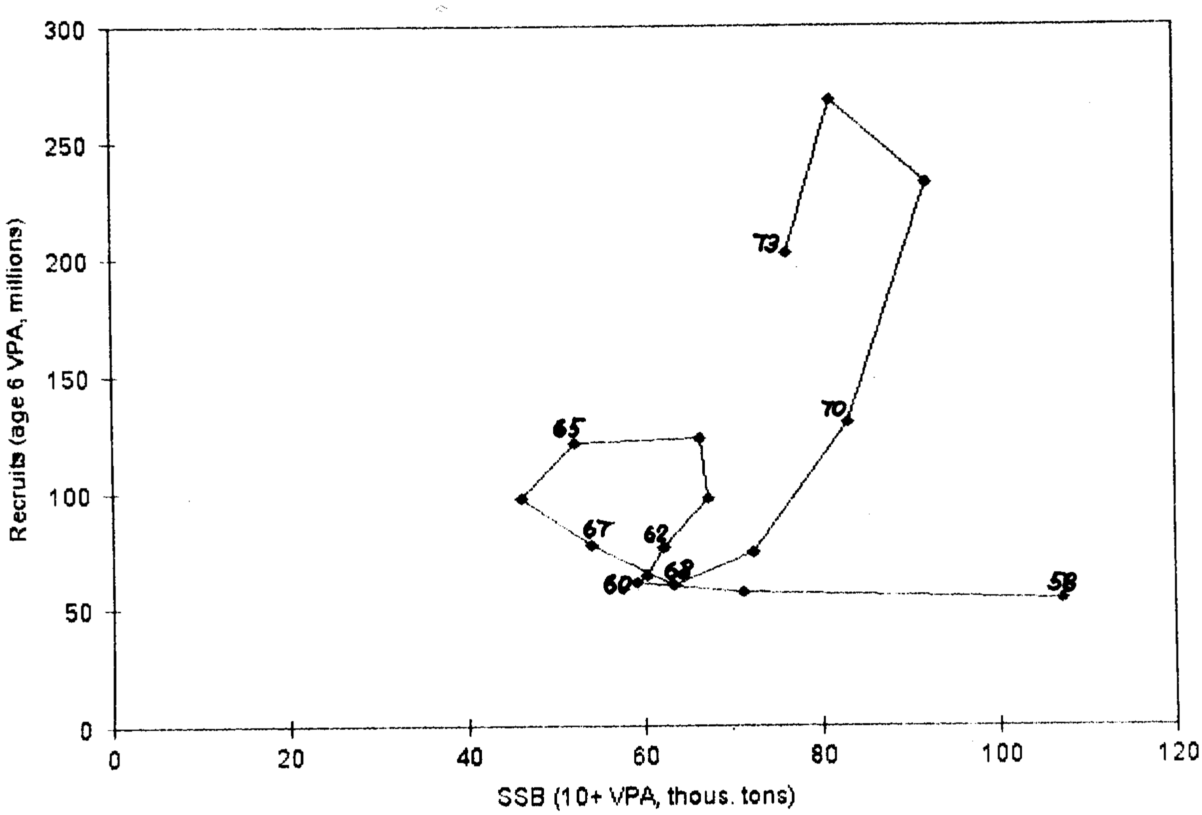

Figure 7. Redfish in Div. 3M: recruits vs SSB scatter plot, 1958-1973.

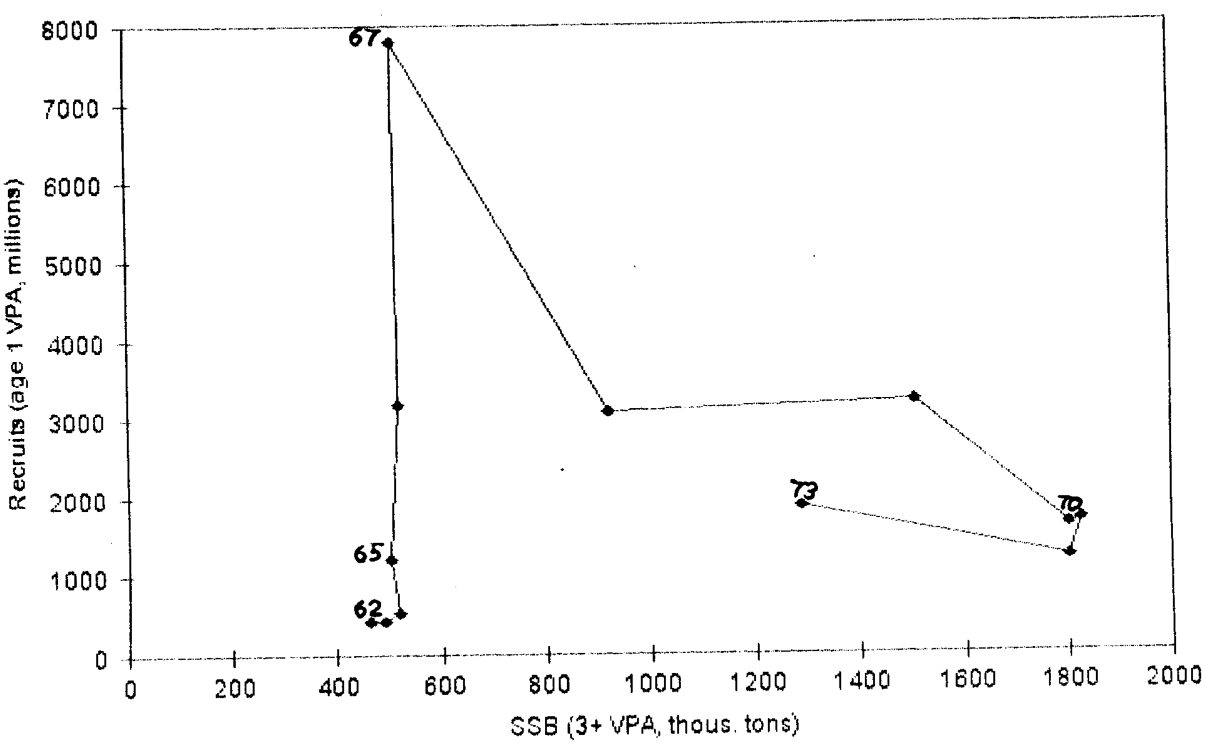

Figure 8. Mackerel in SA 3-6: recruits vs SSB scatter plot, 1962-1973.