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On Interpretation of Plots of "Stock-Recruitment" Relation of Silver Hake (*Merluccius bilinearis*) from the North-west Atlantic

by

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ABSTRACT

Qualitative analysis of “stock-recruitment” relation of silver hake from the North-Western Atlantic Ocean was performed. Various types of curves and actual scatter of points at the plots were considered. The results obtained evidence the periodicity in recruitment and stock abundance of the species considered, which seems to be caused by the cyclical pattern of climatic variability. Analysis of plots also allows to conclude that the environmental factors impact upon silver hake year-classes abundance suppresses the effect of density relation within a wide range of the latter spawning biomass. Therefore, estimation of the reference point (B_{lim}) corresponding to the biomass value below which the probability of recruitment reduce increases, seems to be rather problematic. The assumption is made that the effect of the relation studied is revealed only at very high (close to the maximum) and the lowest levels of spawning stocks observed.

INTRODUCTION

It is well-known that implementation of the precautionary approach strategy in fishery management requires to define and assess several major reference points (criteria), two of which (B_{lim} and B_{buf}) characterize appropriate levels of spawning biomass (Serchuk et al., 1997). Besides, in regards to well researched species it is recommended to use analysis of "stock-recruitment" relation to estimate B_{lim} value. Thus, the "permanent" problem of the latter interpretation arises again.

Silver hake has been selected as the subject of such researches, since it is one of the most researched and abundant commercial species in the North-Western Atlantic. Besides, this species is characterized by apparent and frequent variations of year-classes abundance, which provides favourable prospects to analyse possible relation between the spawning stock, recruitment and environmental conditions especially taking in account availability of long-term observations series.

MATERIAL AND METHODS

Data for "stock-recruitment" plots were obtained from ICNAF and NAFO scientific papers (Almeida and Anderson, 1979a, b, c; Clay and Beanlands, 1980; Showell, 1997). Spawning stock in all cases was determined as the biomass of 2 years old and older hake which provides sufficient accuracy for the purposes of this research. Thus, even in the Scotian shelf area (the nothern part of hake distribution area) 70% of fish is mature at the above said age. Recruitment is determined as abundance of 1 year old fish (occuring in catches for the first time). Selection and drawing various curves, as well as their extrapolation to interception with zero point was performed using PC. Qualitative analysis of relation between recruitment, spawning stock biomass and environmental conditions was carried out. Temperature data observed in different areas of North-Western Atlantic were used.

RESULTS AND DISCUSSION

Scotian silver hake (4VWX)

The history of this species assessment is subdivided into 2 distinct periods (before and after 200-mile zone enforcement in 1997), pooling of which is unlikely due to some reasons (differences in research methods and conditions of age-length sampling). Therefore, "stock-recruitment" analysis was carried out individually for each period (1962-1979 and 1979-1996). The results are presented in Fig. 1-3. Let us start with discussion of Fig. 1 where the curve pattern allows to assume density relation availability, since recruitment abundance increases with increase of spawning stock almost to the maximum observed level of the latter. Only at the number of spawners about 90% of the maximum value a slight turn of the curve towards decrease is observed. Therefore, we may assume that when spawning stock level approaches or reaches maximum the probability of weak year-classes occurence increases. However, on the basis of points scatter in the figure, the actual process of a year-class formation is much more complicated. Thus, 5 approximately equally weak year-classes appeared within the spawning stock abundance 600-2200 mln.ind. And vice versa, at similar number of spawners (at the level of about 1800 mln.ind.) the year-classes abundance varied from 500 to almost 4000 mln.ind. Evidently the factors suppressing to significant extent the density relation impact acted in that case. The points allocation in the figure assumes availability of some recurrence in recruitment abundance dynamics. Thus, a series of weak year-classes in 1962-1966 was replaced by the period of recovery in 1967, approaches the peak in 1971 and was followed by medium year-classes and later on by weak ones. The year of 1980 may be considered as the cycle termination. Let us compare the above facts to the environmental conditions, which may be relevant to a year-class formation. It seems that temperature factor should be included into the latter. Data on annual temperature anomalies of surface water (SST) and near bottom layer of Emerald basin in Scotian shelf (Drinkwater et al., 1996) evidence the following: in early-mid 1960s significant negative anomalies were observed (weak year-classes of 1962-1966). In late 1960s the warming began which lasted during the first half of 1970s (medium and strong year-classes of 1967-1974). During the second half of 1970s the process of cooling commenced (weak year-classes of 1975-1978).

Thus, coincidence of recruitment abundance trends and water temperature is evident during the period considered.

The data obtained during the second period are presented in Fig. 2 and 3. It is apparent that the curve in Fig 2. is similar to the previous one and needs no special comments. However, it should be noted that another curve all turns of which seem to reflect the environmental factors impact, better agree to the points scatter (Fig. 3). Let us follow the recurrence in the latter case. In 1981 the increase of abundance was observed, which continued till 1988. Aterfards a series of weak year-classes appeared (1989-1993). A new cycle is likely to start from 1994 when a series of strong year-classes was observed, including that of 1997 (Data of Canadian-Russian surveys of juvenile hake). It is still unknown when the above stage of a cycle will be finished. Let us see compatibility of the above said and water temperature dynamics in the shelf area during the period considered. In the first half of 1980s significant positive anomalies were observed both in SST and temperature of near-bottom layer of Emerald basin (Drinkwater et al., 1996), which associated with three strong year-classes occurence. The second half of 1980s-eraly 1990s were characterized by almost simultaneous decrease of water temperature and recruitment abundance.

The next warming has started from warm slope water intrusion into the deep-water shelf areas in late 1991-early 1992. Since 1994 successive strong hake year-classes appeared.

Thus, during the whole observation period in general the relation between water temperature and recruitment abundance has been observed which is unlikely the result of a random coincidence. Subsequent researches revealed also quantitative relation between the anomalies and Scotian hake year-classes abundance (Sigaev and Rikhter, 1996).

Silver hake from the Gulf of Main (5Y)

The data for subsequent analysis of "stock-recruitment" relation are presented in Fig. 4 and 5. Evidently, the curve shape in Fig. 4 allows to assume almost straight relation between recruitment abundance and spawning biomass. However, if we consider the points allocation, the latter scatter is similar to that of Scotian silver hake. Thus, several approximately similar weak year-classes were formed in the range of the spawning stock of 30-120 thous.t while at the biomass of 130-140 thous. t the year-classes of 160-470 mln.ind. appeared. Evidently, the environmental factors affect recruitment significantly also. Effect of density relation seems to appear only at the lowest observed level of spawning biomass which was likely insufficient to form strong year-classes in average conditions for survival. The curve shown in Fig. 5 (looking like Loch-Nesse monster) better corresponds to the points scatter and assumes 3 periods of the population abundance: high (1955-63), decreasing and low (1964-70) and low, however, starting to recover (1971-73).

Let us see if the above periods correspond to temperature variability in the Gulf of Main (Trites and Drinkwater, 1983; Drinkwater et al., 1996). In 1950s high SST anomalies were observed while in 1958-63 the temperature was at the average long-term level or slightly below (strong year-classes of 1955-63). Afterwards cooling occured and in 1964-68 high negative temperature anomalies were observed (weak year-classes of 1965-70). In 1970s that process changed into the opposite one and the indications of abundance recovery (year-classes of 1971-73) appeared.

Thus, rather good coincidence of recruitment trends and water temperature was observed in the latter area also.

Certainly, unfavourable conditions of environment may be enhanced by shrimp fishery commenced in 1960s, during which large amount of young hake seemed to be caught (Almeida and Anderson, 1979c).

Silver hake from Georges Bank (5Ze)

Let us consider Fig. 6 and 7 which contain the information required. The curve of Fig. 6 is similar to that of Riker's type with a peak of spawning biomass of about 70% of the maximum observed. Concerning the actual points allocation, trends may be observed similar to those in the previous areas, i.e. a series of approximately similar weak year-classes occure within the wide range of the spawning biomass, while recruitment abundance varied significantly by years at the same biomass level.

The pattern of points scatter allows to assume recurrency of hake recruitment and stock dynamics which was noted by American scientists (Almeida and Anderson, 1979a) as long ago as in 1979. Fig. 7 provides more illustrative confirmation of the above said. As is shown, the period of abundance increase had started in 1957-58 and continued till 1962, then the phase of long-term decrease occured and the lowest point was achieved in 1969. It was the end of the cycle. The new one is likely to begin in 1971-73.

Let us compare observed trends of the stock dynamics and temperature conditions during the period considred. Assuming similarity of SST trends in the

Georges Bank area and in the Gulf of Main, high positive anomalies should be noted in the latter area during 1950-1957 (Trites and Drinkwater, 1983), some decrease (mianly to average long-term level) during 1958-63 and sharp cooling during 1964-68. Negative SST anomalies were observed in the Georges Bank area during 1968-72 (average year-classes of 1971-73))Karaulovsky and Sigaev, 1976).

Thus, in that area the correspondence between water temperature and hake recruitment abundance was observed.

Silver hake of Mid-Atlantic Bight (5Zw+6)

The comparison of curve and points scatter in Fig. 6, 7 (5Zl) and 8, 9 (5Zw+6) reveals considerable similarity between them, excluding a short time period (1971-72). The above similarity is likely to be interpreted as indirect evidence of a single self-reproduced population inhabiting the southern Georges Bank area and Mid-Atlantic Bight. If this assumption is true, almost total similarity of hake recruitment trends in Georges Bank and Mid-Atlantic Bight is quite natural. In any case, impact of environmental conditions upon the reproduction process seems to be similarly strong in the latter area and mainly acts in the same direction as in the former area. Assumption on significant role of environmental factors in silver hake recruitment in the Southern New England - Mid Atlantic had been proposed by American scientist already in 1979 (Almeida and Anderson, 1979b).

CONCLUSION

Results of researches performed allow to assume recurrence in dynamics of silver hake recruitment and stock of Scotain area, Georges Bank and Mid-Atlantic Bight which seems to be stipulated by recurrence of climatic variations, primarily by water temperature fluctuations. Besides impact of external factors upon year-classes strength formation supress effect of density relation within a wide range of spawning biomass. Definition of a fixed reference point (B_{lim}) , corresponding to the spawning biomass value below which recruitment decrease becomes more probable, is rather problematic. Concerning the object considred we may assume that the impact of relation researched is revealed only at very high (close to maximum) and the lowest biomass levels observed. In the latter case average environmental conditions for young fish survival seem to be insufficient to produce strong year-classes.

In silver hake fishery management recurrency in its stock dynamics should be taken into account to regulate exploitation rate in compliance with the cycle phases.

REFEERENCES

Almeida F.P. and E.D.Anderson. 1979a. Status of the Georges Bank silver hake stock-1978 ICNAF Res.Doc.79/84.Ser.No.5446,11p.

Almeida F.P. and Anderson. 1979b. Status of the southern New England - Middle Atlantic silver hake stock-1978.ICNAF Res:Doc.79/85.Ser.No.5447,11p.

Almeida F.P. and E.D.Anderson. 1979c. Status of the Gulf of Maine silver hake stock 1978. ICNAF Res.Doc.79/88.Ser.No.5450,12p.

Clay D and B.Beanlands. 1980. Silver hake (Merluccius bilinearis) in Division 4VWX: a stock assessment and estimate of total allowable catch (TAC) for 1981. NAFO SCR Doc.80/87.Ser.No. N141,14p.

Drinkwater K.F., E.Coolbourne and D.Gilbert. 1996. Overview of environmental conditions in the Northwest Atlantuc in 1995. NAFO Sci.Coun.Studies, No.27, p.1-37.

Karaulovsky V.P. and I.K.Sigaev. 1976. Long-term variations in heat content of the waters on the Northern Atlantic shelf. ICNAF Res.Doc.76/2. Ser.No. 3760, 9p.

Serchuk F., D.Rivard, J.Casey and R.Mayo. 1997. Report of the ad hoc working group of the NAFO Scientific Council on the precautionary approach. NAFO SCS Doc.97/12. Ser.No.N2911, 61p.

Showell M.A. 1997. Assessment of the 4VWX silver hake population in 1996. NAFO SCR Doc.97/69. Ser.No.N2903, 27p.

Sigaev I.K. and V.A.Rikhter. 1996. On relationships of some commercial fish species year-class abundance and hydrological conditions in the Northwest Atlantic. NAFO Sco.Coun.Studies,No.24, p. 87-90.

Trites R.W. and K.F.Drinkwater. 1983. Overview of environmental conditions in 1982 within the NAFO convention area. NAFO SCR Doc.83/23.Ser.No.N674, 26p.

Fig.1. Plot of stock-recruitment relation for silver hake from 4VWX, 1962-79

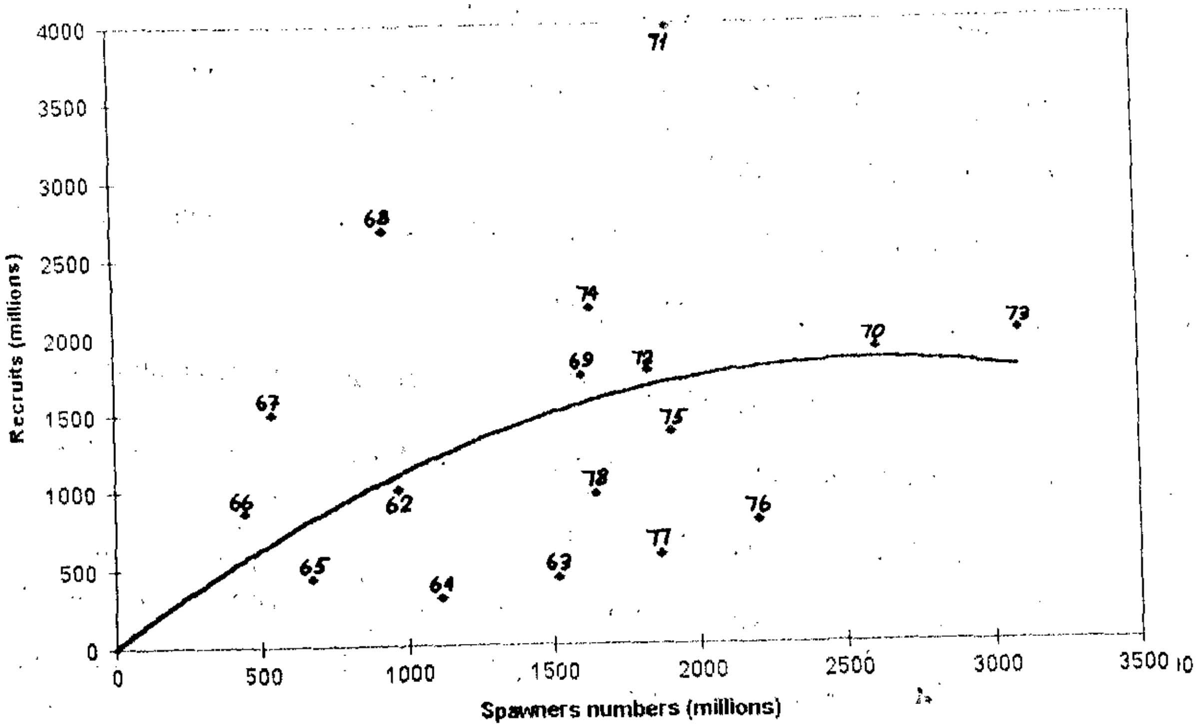

Fig.2. Plot of stock-recruitment relation for silver hake from 4WVX, 1979-1996

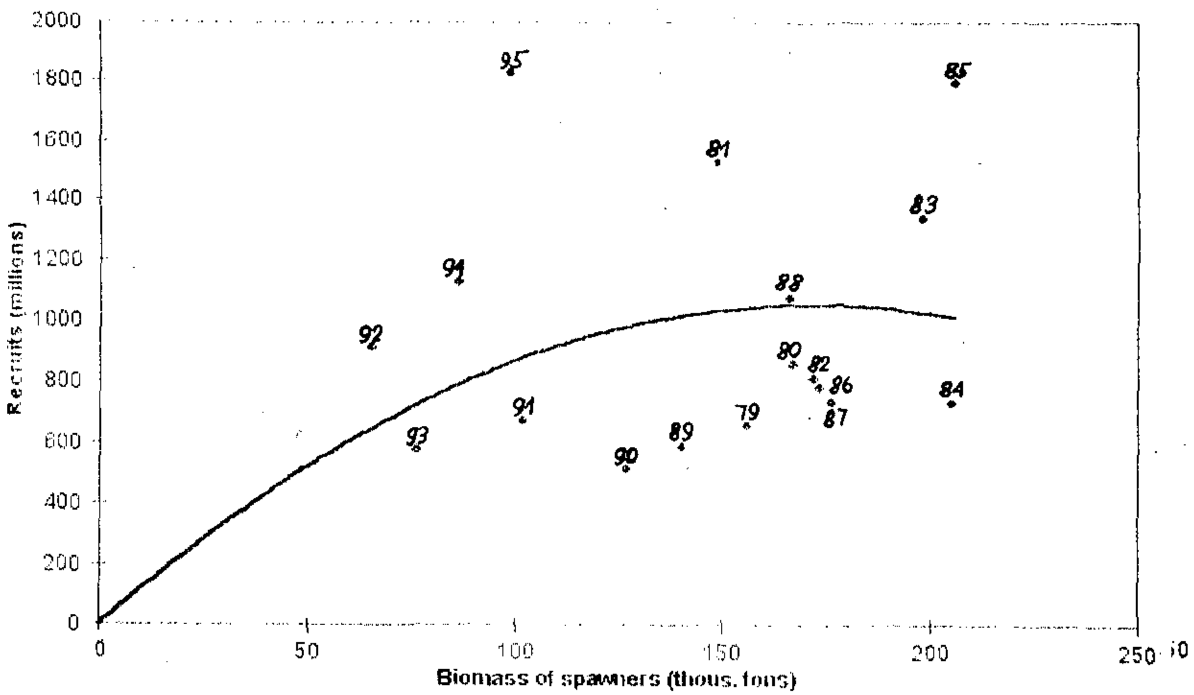

Fig.3. Plot of stock-recruitment relation for silver hake from 4VWX, 1979-1996

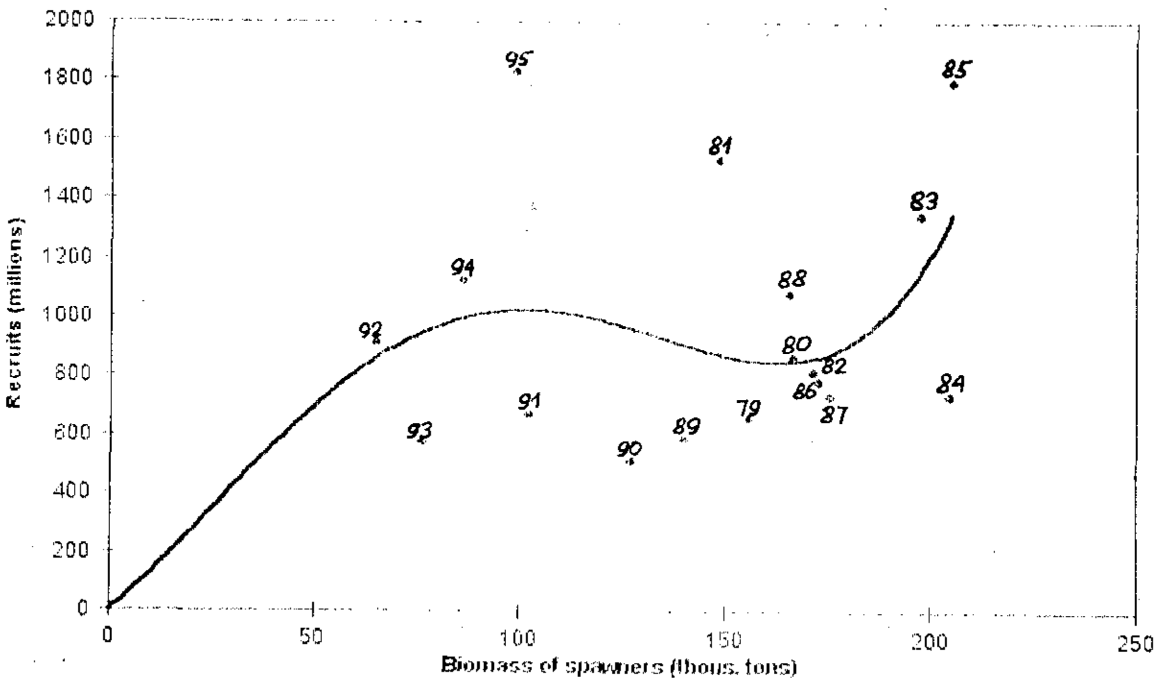

Fig.4. Plot of stock-recruitment relation for silver hake from 5Y, 1955-1974

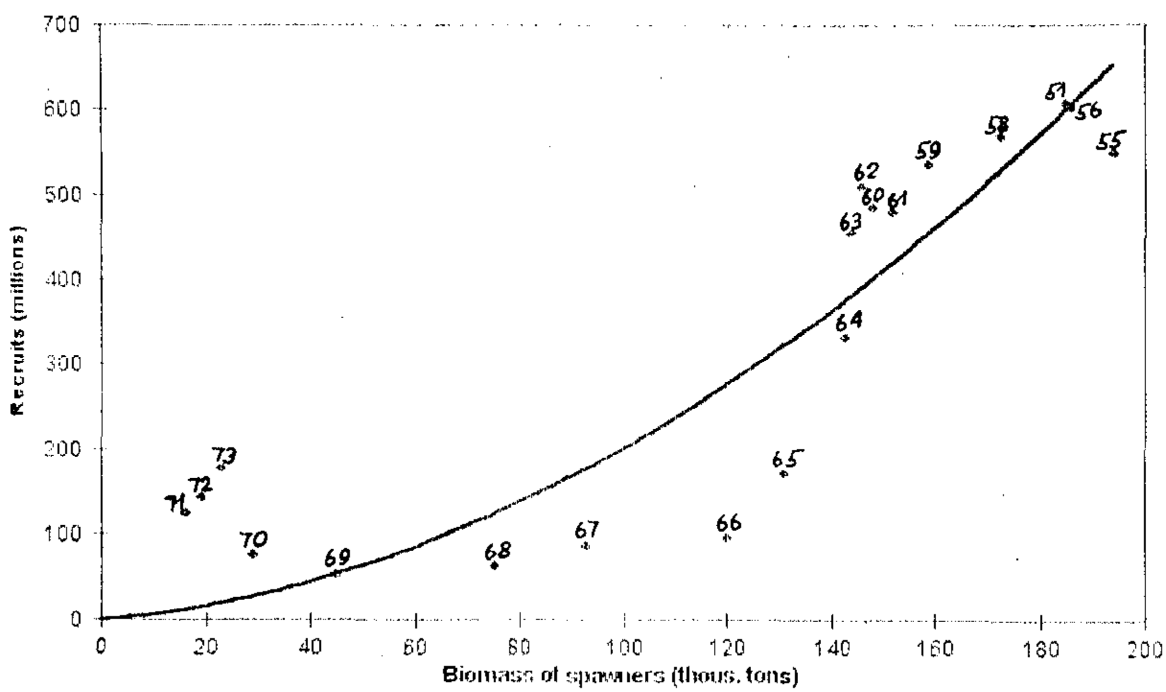

Fig.5. Plot of stock-recruitment relation for silver hake from 5Y, 1955-1974

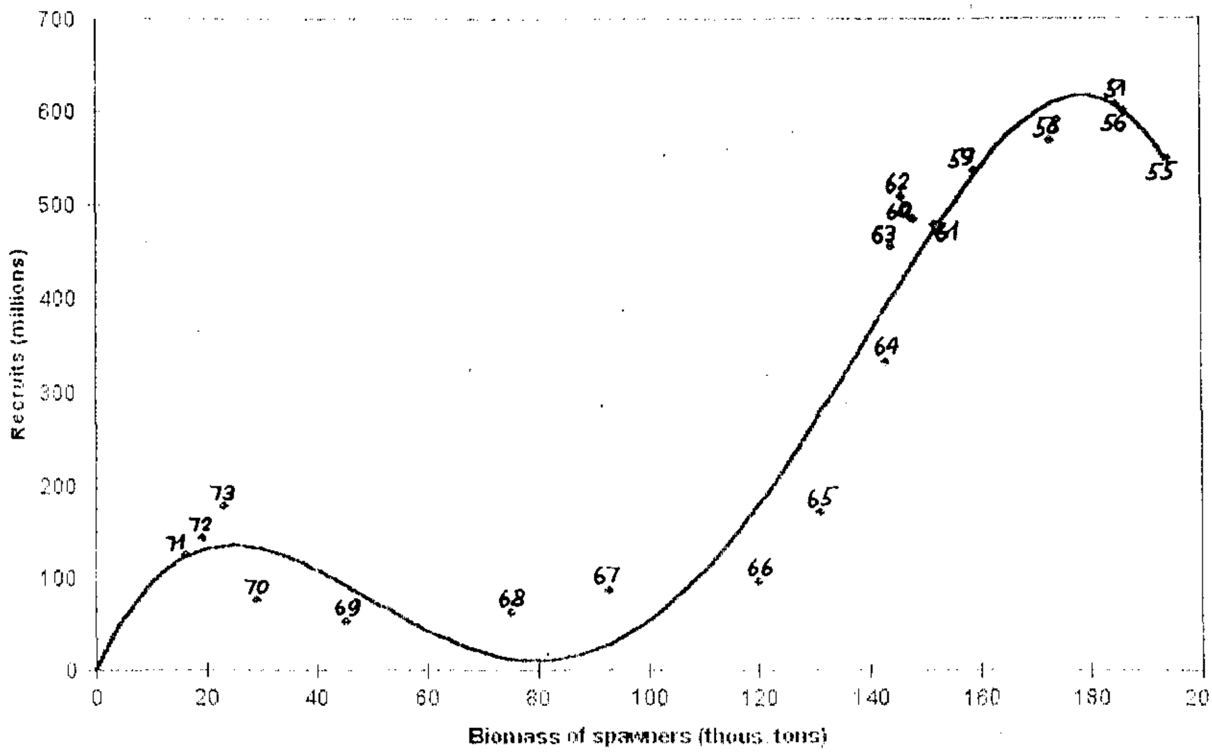

Fig.6. Plot of stock-recruitment relation for silver hake from 5Ze, 1955-1974

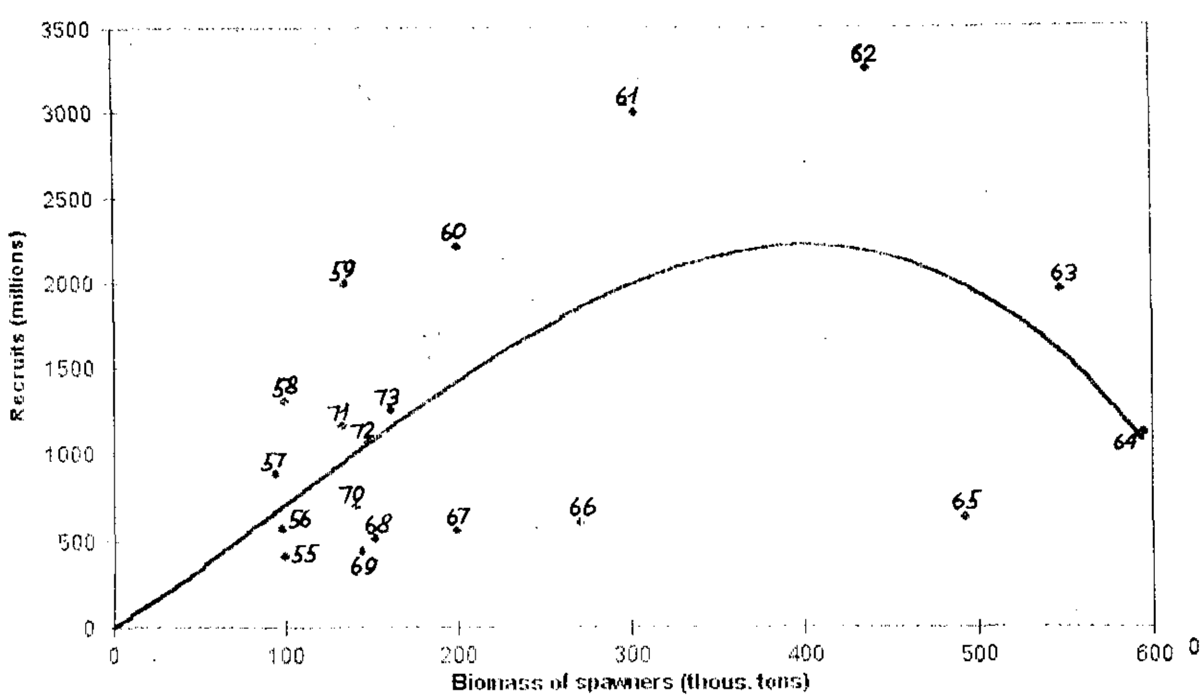

Fig.7. Plot of stock-recruitment relation for silver hake from 5Ze, 1955-1974

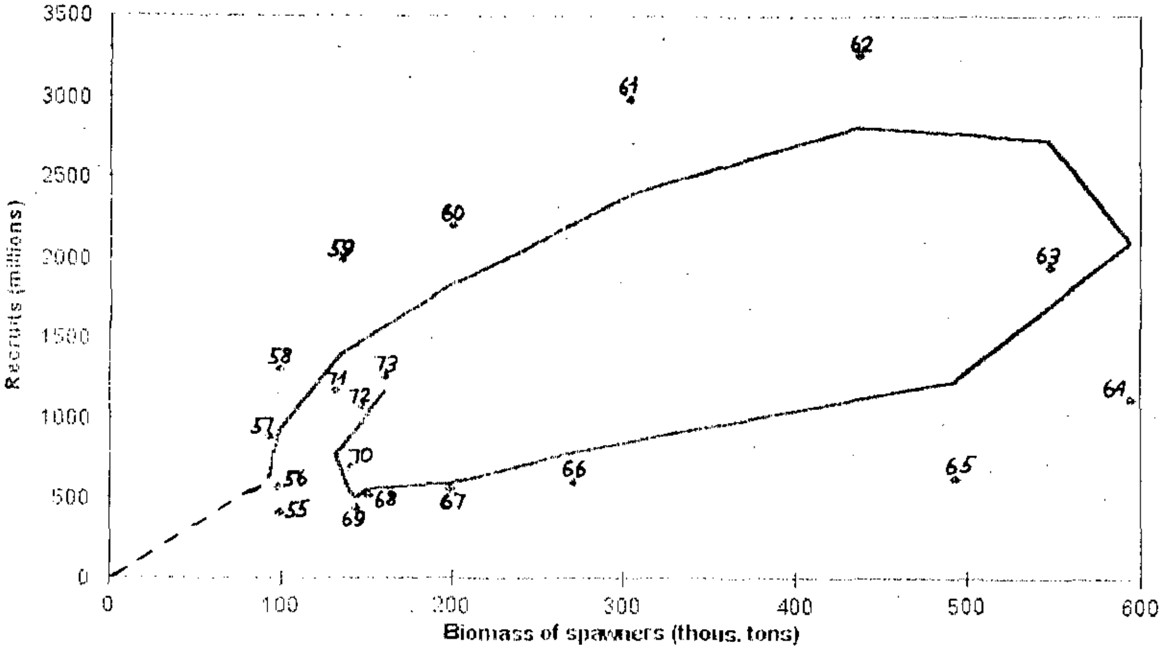

Fig.8. Plot of stock-recruitment relation for silver hake from 5Zw+6, 1955-1974

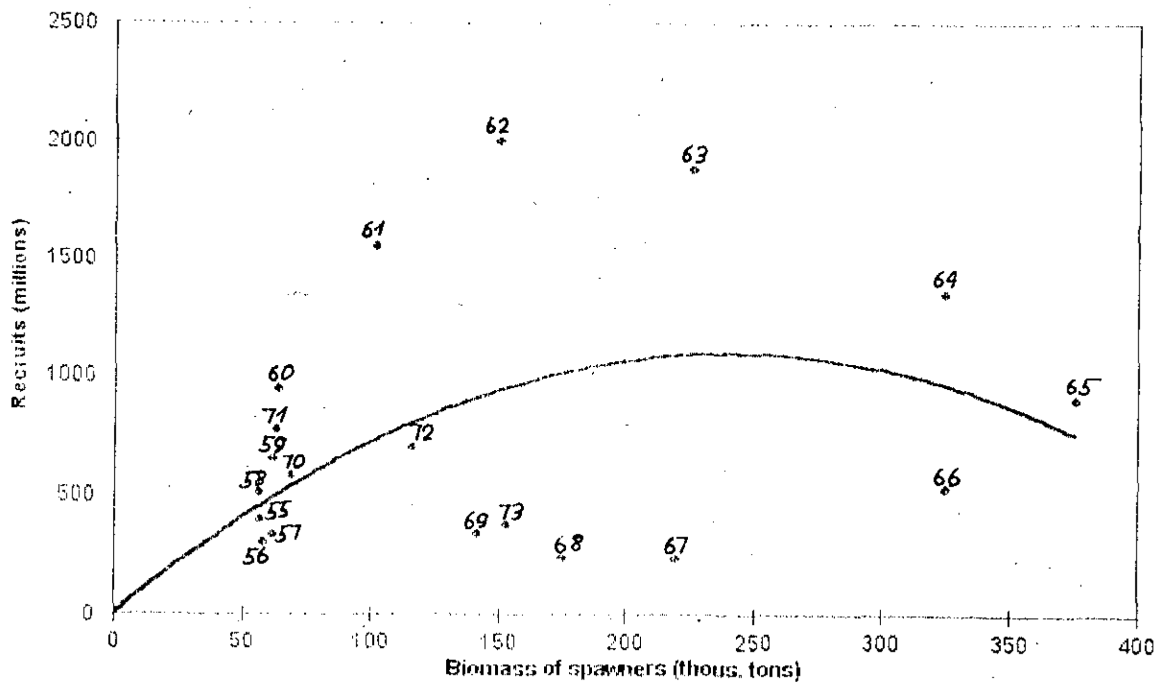

Fig.9. Plot of stock-recruitment relation for silver hake from 5Zw+6, 1955-1974