Northwest Atlantic Fisheries Organization

Serial No. N2905 NAFO SCR Doc. 97/71

SCIENTIFIC COUNCIL MEETING – JUNE 1997

Observations on Maturation, Recruitment and Spawning Stock Biomass in Yellowtail Flounder on the Grand Bank

by

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Abstract

Estimates of 50% maturity at size and age, recruitment variability and spawning stock biomass (SSB) were produced for yellowtail flounder on the Grand Bank, NAFO Div. 3LNO for the period 1975-95. Males mature at a smaller size and younger age than females. Both age and length at 50 % maturity declined in males in recent years. A similar decline in age but not length was evident in females. Both relative cohort strength and SSB were below the long term average from 1987 to 1995. There was no obvious evidence of a S/R relationship.

Introduction

The relationship between stock and recruitment in fish stocks has a long history of debate. Because it is generally difficult to find a significant statistical relationship there is often doubt whether one exists or whether it exists in every stock. For example, Iles (1994) recently studied 20 flatfish stocks for which suitable data was available and analyzed this data with a variety of models including Beverton and Holt, Ricker and Cushing models. He found only 6 stocks, which showed a statistical relationship. The data source for these models was either catch at age data from research vessel surveys or VPA.'s. The quality of such data is lessened by the fact that they are rarely separated out by sexes. Until now such has been the case for yellowtail flounder on the Grand Bank.

The ability to accurately determine spawning stock biomass plays an important role in the estimation of stock recruitment relationships. Spawning stock biomass of a stock is a function of the biomass at each age or length and the proportion of the fish at each age or length that are mature and will spawn. Knife-edge estimates of maturity often do not accurately reflect these proportions mature and do not take temporal changes in maturation into account. There are many examples of temporal changes in maturity at age and/or size within fish populations (Beacham, 1983; Bowering, 1989; Rijnsdorp, 1989, Jørgensen, 1990; Morgan et al. 1997). Even small changes in age at maturity can have a significant impact on the estimation of population growth rate and potential yield from a fishery (Welch and Foucher, 1988). As well, there is a potential for changes in age at maturity to be an indicator of stress in populations so that examination of the trends themselves may be important (Trippel, 1995).

The purpose of this study was to first produce estimates of maturity at age and size and to second to estimate spawning stock biomass and recruitment variability for yellowtail flounder in Div. 3LNO. This represents a first approach to making observations on a reliable data set for stock-recruitment in this stock.

Methods

Maturity data from Canadian spring surveys in Div. 3LNO from 1975-95 were used in the analyses. Fish were assigned to the category 'mature' and 'immature' by visual examination of the gonads based on the criteria of Templeman *et al.* (1978). The first stage in this scheme was classed as immature and all other stages show some evidence of maturing to spawn or of having spawned and were classed as mature. The 'other' or 'unknown' category was excluded from analyses. Because of the length stratified collection of otoliths the calculation of proportion mature at age included a weighting by the population number at length (Morgan and Hoenig, 1997). The proportion mature at length was simply the number mature at a given length divided by the total number at that length. Estimates of proportion mature at age and length and of age and length at 50% maturity (A_{50} and L_{50}) were produced for each year and sex using Probit analyses with a logit link function (SAS Institute Inc. 1989). Estimates were produced for Div. 3LNO stock after first weighting the observations for each Division by the population number in that Division. Only the results for years in which there was a significant fit of the model to the data are presented.

Spawning stock biomass was derived using estimates of population numbers of female fish adjusted by average weight and percent mature. Estimates of relative cohort strength were derived from a multiplicative analysis of ages 2-5 from the 1975-95 spring groundfish surveys of the Grand Bank (see Walsh et al. 1997 for details). These estimated cohort strengths were exponentiated following bias correction and plotted

Results and Discussion

Age at 50% maturity for males and females are shown in Fig. 1. Male A_{50} showed an increase from age 4.7 yr. in 1976 to 5.3 yr. in 1981, remaining stable till 1987 and declining from age 5.5 yr. in 1988 to 4.4 years in 1995. Female A_{50} was variable from 1977-82 and ranged from 5.5 yr. to 7.4 yr.. A gradual upward trend was evident from 1984 value of 6.2 yr. to 6.8 yr. in 1988 and this was followed by a gradual downward trend to 6.1 yr. in 1993.

Length at 50% maturity for males and females are shown in Fig. 2. L_{50} showed an upward trend from 26 cm in 1977 to 29.4 cm in 1982 and from 1984 there was a gradual decline from 30 cm to 25 cm in 1995. These trends were similar to those described above for A_{50} . Female L_{50} showed an upward trend from 33.7 cm in 1976 to 36.8 cm in 1978 and was followed by a decline to 34 cm in 1979. Since that time there were no obvious trends in the data and the long term average L_{50} was 34 cm.

Annual differences in age and length at 50 % maturity can be caused by a number of factors chief among them are: growth rates, geographical area, year class strength, size of SSB and environmental conditions. In order to understand some of the trends it shall be necessary to examine the effect of these covariates, in particular differences in length at first maturity.

Maturity at age and size has also been examined for American plaice in Div. 3LNO (Morgan et al. 1996; 1997). This species has shown large declines in size and age at maturity over the 1975-95 time period. For example, female L_{50} decreased from 39 to 33 cm and A_{50} from 11 to 8 years.

The relative cohort strengths are plotted in Fig. 3 and show that there has been considerable variability around average recruitment over the time period. Cohort strength has been below the long-term average every year since 1981; the exception being the 1986 cohorts. The SSB in Fig. 4 also showed a lot of variability around the long-term average of 35,000 t and in latter years the SSB was at extreme low levels since 1987.

Fig. 5 shows the S/R data using the relative cohort strengths plotted against female SSB. Recruitment appears to vary widely over a narrow range of SSB and the data may have some temporal trends. Recruitment may be independent of stock size and whether this is due to some environmental or density dependence effects is not known. Walsh (1994) examined recruitment variability in 14 populations of American plaice in the North Atlantic and suggested that recruitment variability in Grand Bank plaice was being regulated by density dependent processes in the juvenile stage. This could be a feature of flatfish at mid-latitudes where juveniles share their ocean habitats with adults of the same species. Morgan et al. 1997 also found that recruitment varied widely over a variety of SSB sizes and that temporal trends in the data may mask the true relationships. In both species, with such low SSB in the latter years it may not be biologically possible to produce a high level of recruitment at low stock size.

Commonality of variability in recruitment, SSB and S/R relationships in yellowtail flounder and American plaice requires further investigations. Similar trends may be expected in the data since they share common life histories and habitat in the offshore.

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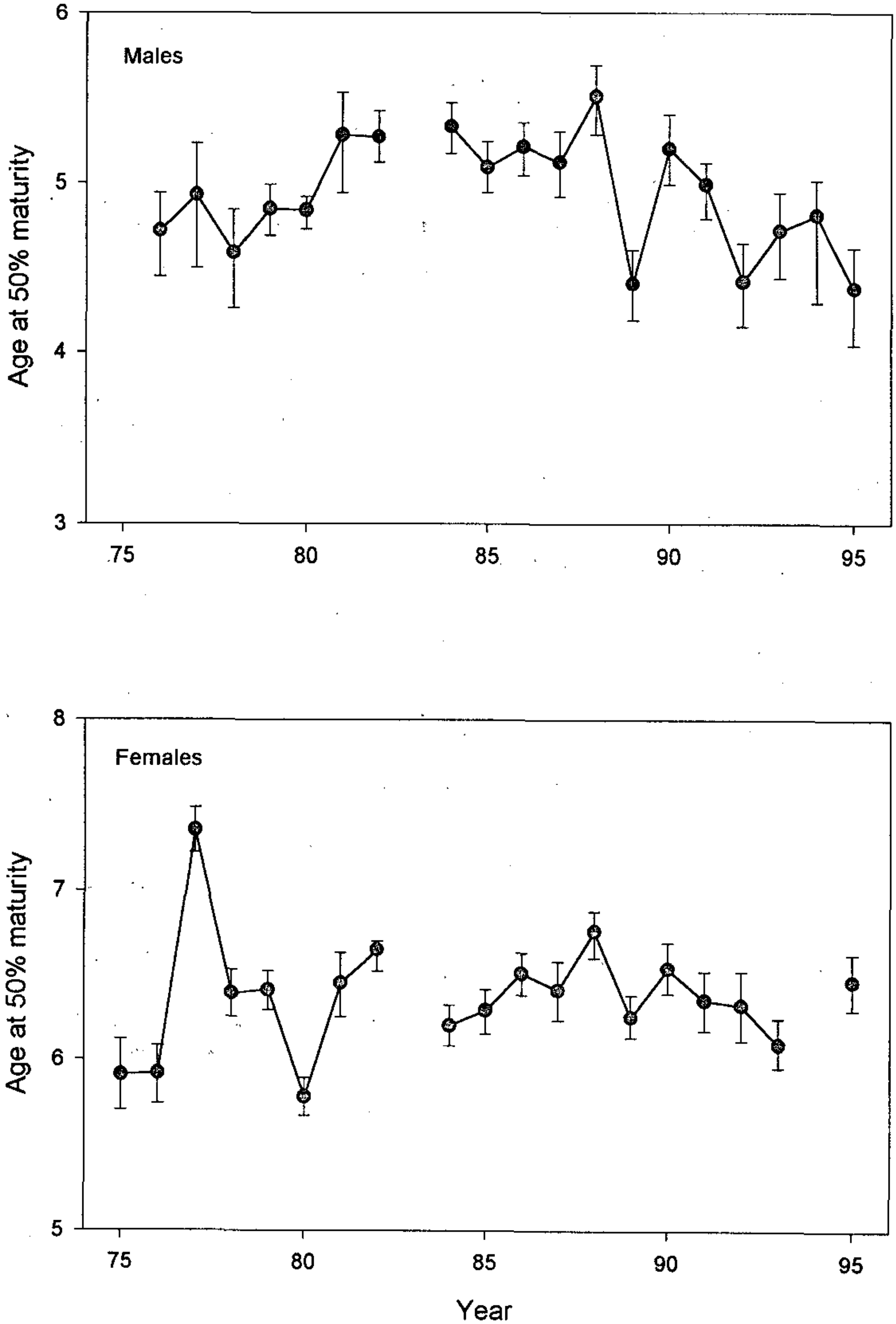

Figure 1. Age at 50% maturity for male and female yellowtail flounder for Div. 3LNO combined.

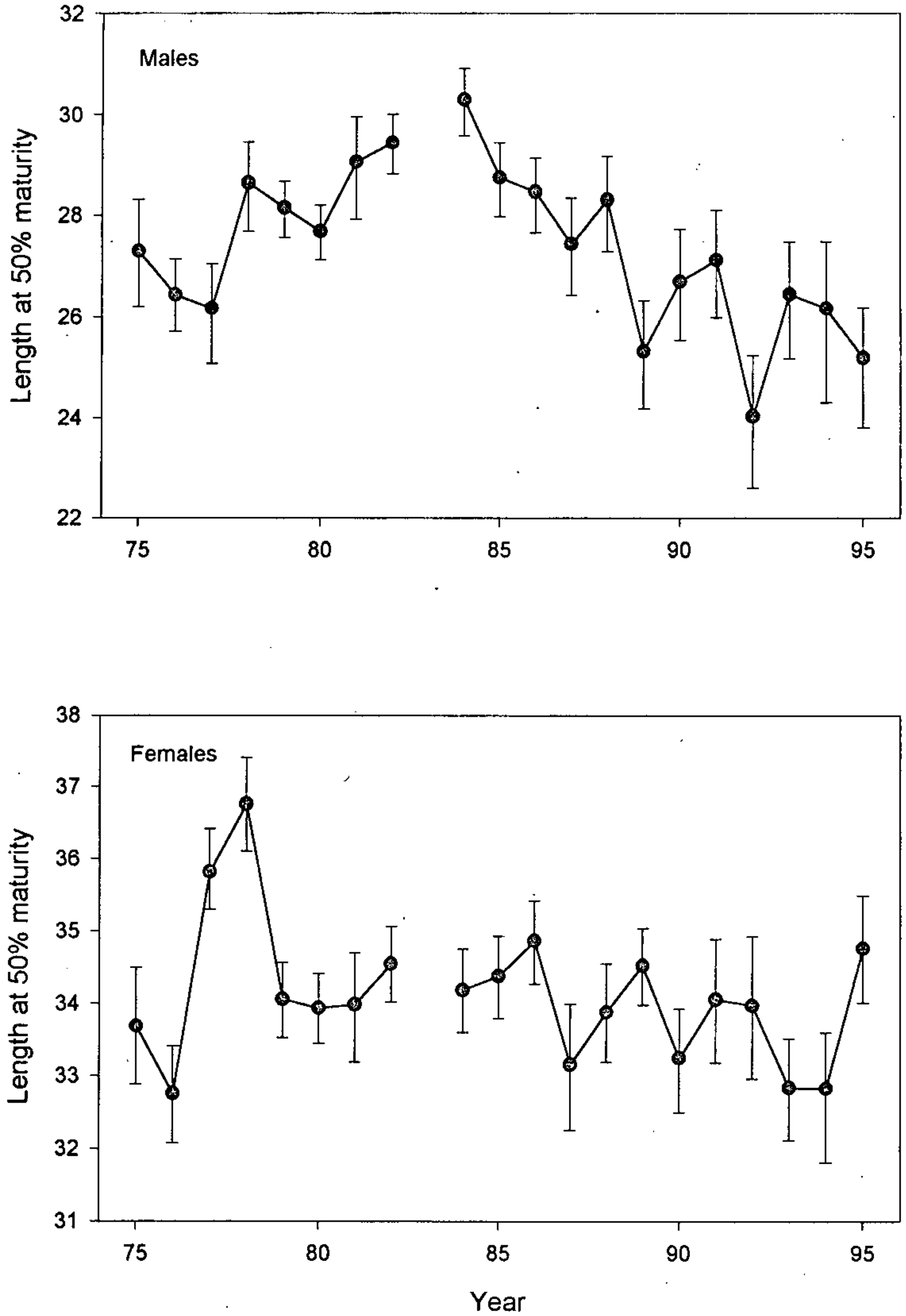

Figure 2. Length at 50% maturity for male and female yellowtail flounder for Div. 3LNO combined.

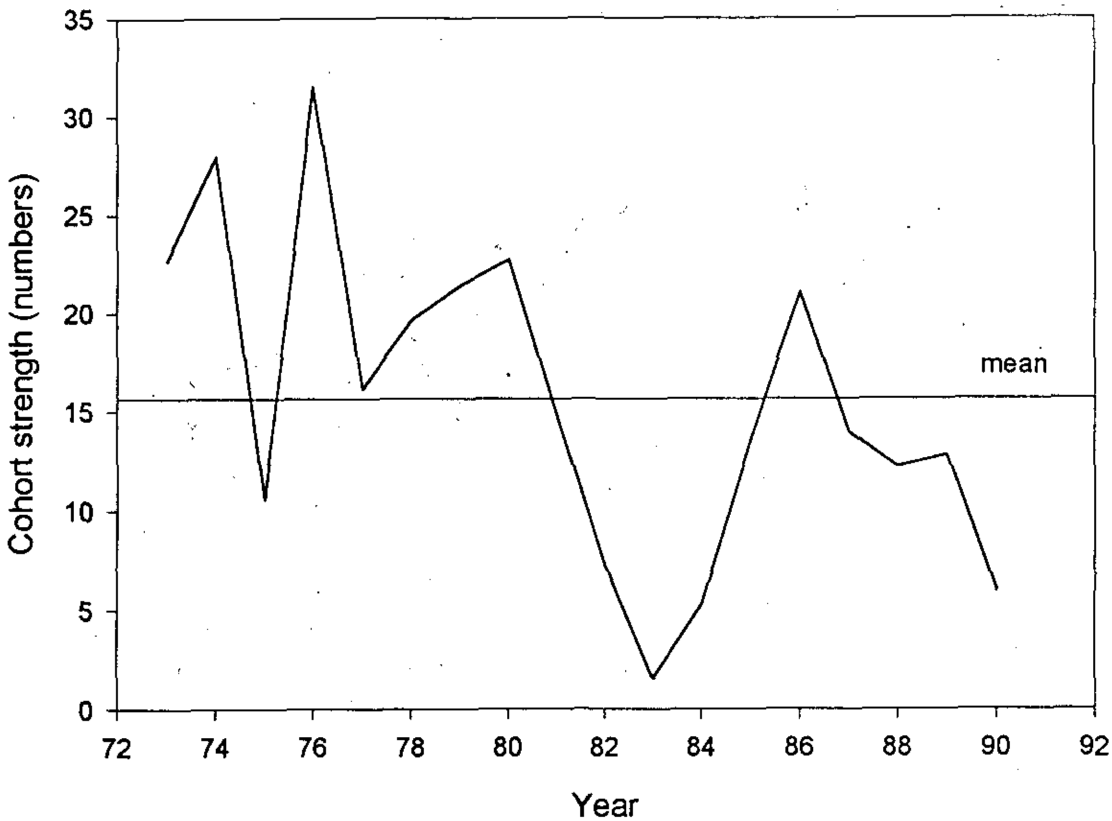

Fig. 3. Relative cohort strength derived from multiplicative analysis of ages 2-5 year from the 1975-95 spring groundfish time series.

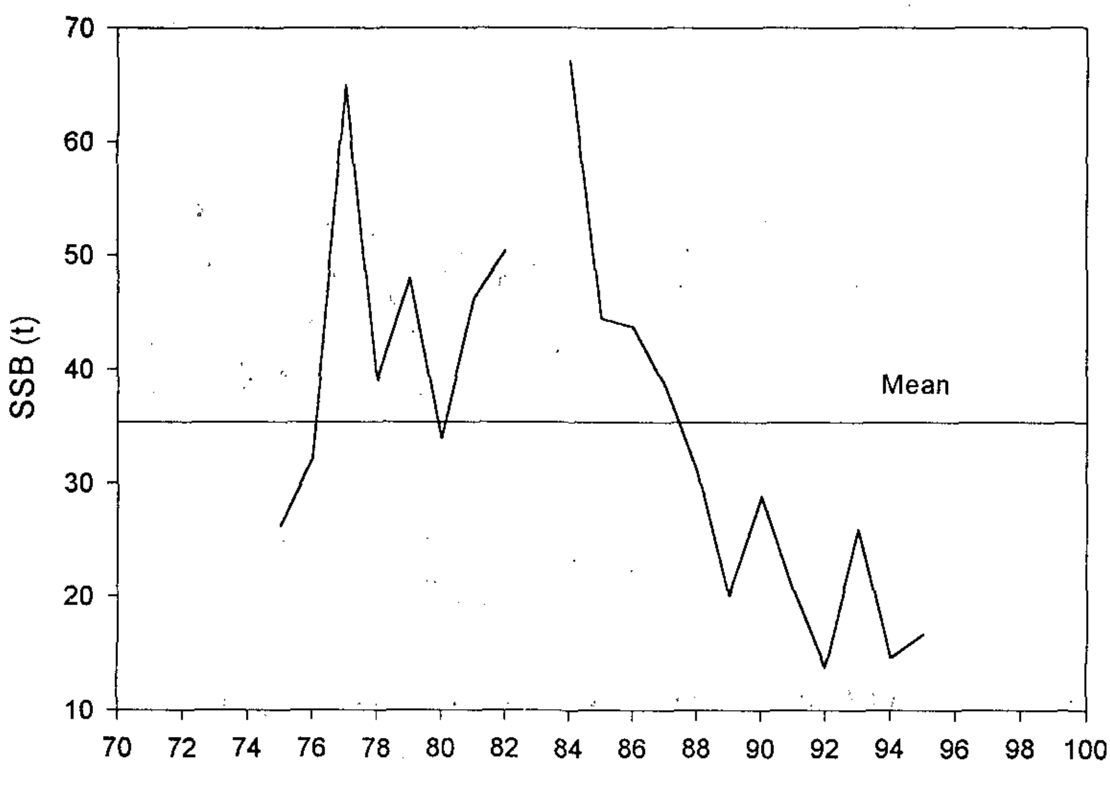

Fig. 4. Variation in spawning stock biomass based on aplication of a maturity ogive to population numbers at age from the 1975-95 spring groundfish series

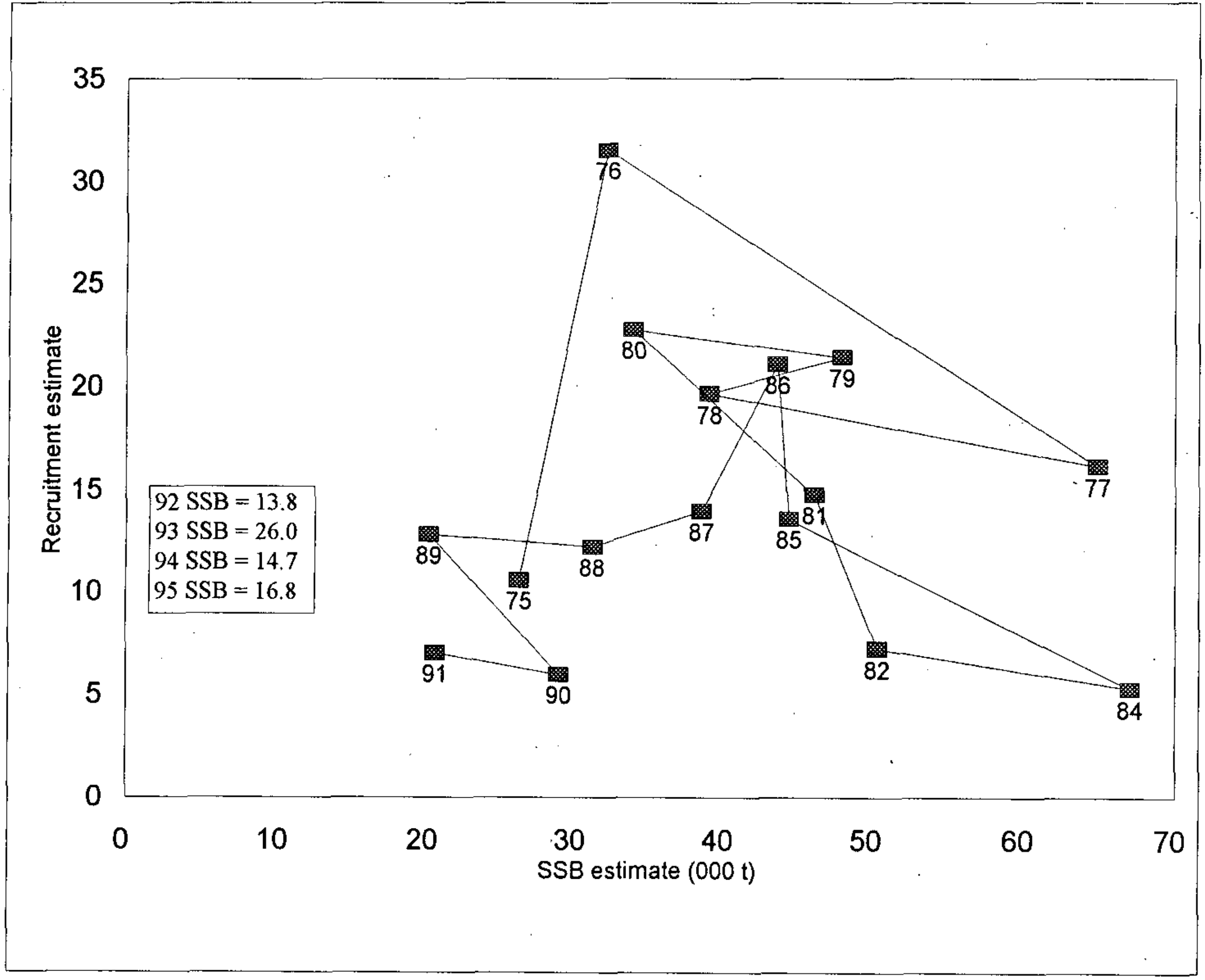

Fig. 5. Stock recruitment plot for yellowtail flounder in Div. 3LNO.