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Migration patterns of short-finned squid and fishery effects inferred from research survey and fishery data

by

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Abstract

Information was reviewed toward inferring whether short-finned squid fisheries in Subareas 3+4 affect the resource in Subareas 5+6. Trends in distribution, size, and maturity from late fall surveys on the slope of the continental shelf throughout Subareas 3-6 indicate that squid move off the shelf in all areas during late fall. Comparison of the seasonal timing of fishery peaks among subareas suggests that squid from Subareas 3+4 do not become available to the fishery in subareas 5+6 later in the season. This was supported by comparison of size and sex composition, from various sources, among subaraes. Comparison of survey and fishery trends showed that peak Subarea 3+4 catches during 1975-1981 were associated with sustained high survey catch rates in subareas 5+6 near the end of the fishing season. Although the large catches in Subareas 3+4 in the late 1970's did not appear to adversely affect the resource in Subareas 5+6, the effects of fishing throughout Subareas 3-6 during the period of total stock decline in the early 1980's remain unknown.

Introduction

Fisheries for short-finned squid (Illex illecebrosus) throughout the Northwest Atlantic Ocean likely target a common single stock (Dawe and Hendrickson 1998). Therefore there is some concern that fisheries in most northern areas (NAFO Subareas 3 and 4) may affect the resource to the South, in NAFO Subarea 5 and Statistical Area 6. For such an effect to be possible would require that squid from northern fishery areas may become available to the SA 5+6 fishery later in the year. This paper reviews data on distribution and biological characteristics from fisheries and surveys throughout the Northwest Atlantic, toward inferring migration patterns, particularly during late fall. Also, relative exploitation rates are estimated and compared with survey biomass indices to directly investigate whether fisheries in northern areas affect the resource to the South.

Distribution Patterns

Survey trends

Dawe and Hendrickson (1998) reviewed seasonal distribution in SA 5+6 based on bottom trawl surveys and showed that squid which had been advected northeastward by the Gulf Stream in winter move onto the edge of the continental shelf in spring and become broadly distributed across the shelf by summer (Fig. 1). In autumn densities are again greatest near the shelf edge, suggesting a net off-shelf migration.

A similar distribution pattern is evident in more northern areas. Dawe et al. (1998) showed that squid move onto the slope of the continental shelf in SA 3 during May-June and appear inshore at Newfoundland as early as July, when near-shore bottom temperatures exceed 5°C. Dupouy and Poulard (1980) showed that in October 1979 squid were concentrated on the slope of the St. Pierre Bank, seaward of the 6^{o}C bottom temperature isotherm (Fig. 2).

Amaratunga et al. (1980) conducted surveys on the slope of the Scotian Shelf and seaward of the Shelf during October-November 1979 to investigate the late-season migration pattern. Their bottom trawl survey showed that density was greatest at 251-350m depths during October 23-November 10, whereas catch rates were greatest at 451-850m depths during November 11-29. They also noted a clear increase in size and maturity with depth and concluded that a deep-water migration was evident. They also achieved regular catches with midwater trawl seaward of the shelf, further supporting a net off-shelf migration.

Data are also available from an October 21-November 16, 1979 bottom trawl survey (Whittaker 1981), which extended from Georges Bank to Cape Canaveral, the southern limit of the known distribution of short-finned squid. That survey also showed an increase in squid size with depth, with largest squid most prevalent at depths greater than 500m, both north and south of Cape Hatteras.

Fishery trends

The fishing season generally occurs earlier in the South than in the North. During 1982-96 the fishery in SA 5+6 usually extended May-November and landings per unit effort (LPUE) peaked in May or June during 7 of those 12 years (Hendrickson et al. 1996). At the northern extreme in SA 3, the Newfoundland inshore fishery typically extends July-November and peak catches have occurred between Aug and Oct. throughout 1975-98, with September representing the peak in 13 of those 24 years. In 1977 the small-scale inshore fishery in SA 4 peaked in September, two months later than the offshore peak in CPUE (Amaratunga et al. 1978). The earlier peak in the fishery to the south is consistent with an off-shelf southward spawning migration.

Biological Characteristics

Size

Late-season size was compared between extreme fishery areas toward inferring whether the southward spawning migration is along the shelf or oceanic. It is known that largest squid of both sexes emigrate from SA 3 and 4, creating the artifact of asymptotic, and sometimes negative, growth. Therefore it can be assumed that if southward migration is along the shelf, then late fall size would be largest in the most southern fishery area. In both 1975 and 1976, two years of high squid abundance, it was possible to compare late fall modal length from the SA 3 inshore jig fishery with that for the largest modal group sampled in SA 5+6 by bottom trawl (Table 1). It is clear that modal mantle length of the largest modal group was not noticeably larger in SA 5+6 than in SA 3. Mesnil (1977) noted that largest bottom trawl catches between Georges Bank and Cape Hatteras during Oct 28-Dec 6, 1976 occurred at greatest depths. He concluded that ‘the offshore migration was developing, so that many large squid were already out of reach of the trawl’.

Sex Ratio

A seasonal decline in proportion of males is commonly observed inshore at Newfoundland (Fig. 3). Similarly, Dupouy and Poulard (1980) noted that males comprised only 37% of squid caught by bottom trawl on the slope of the St. Pierre Bank during October 1979. This decline in males has been attributed to earlier maturation and emigration of males than females (Lange 1980, Dawe and Hendrickson 1998). This implies that late-season sex ratios would favour males in the most southern fishery area, if migration is along the shelf. However Lange (1980) noted males tend to decline throughout the season in SA 5+6 as well. She found significantly fewer males than females in both 1976 and 1977, consistent with low prevalence of males late in the season at Newfoundland in those years (Fig. 3).

Comparison of fishery and survey trends-Relative Fishing Mortality

It has recently been concluded that short-finned squid throughout SA 3-6 likely represents a unit stock (Dawe and Hendrickson 1998). To investigate whether fishery removals in SA 3+4 has any effect on the resource in SA 5+6, relative fishing mortality estimates were calculated for SA 3+4 by dividing the annual SA 3+4 landings by the annual SA 4 July bottom trawl survey kg/tow (Rivard et al.1998). A second series of relative fishing mortality was generated by dividing the annual landings by the annual SA 4 September bottom trawl survey no/tow. The September series is probably the more appropriate as the Sept survey more closely corresponds to the fishery peak than does the July survey (Dawe et al., this meeting). Both series of relative F were compared with the SA 5+6 autumn bottom trawl survey kg/tow. If the fishery in SA 3+4 affects the resource in SA 5+6, then negative relationships would be expected, because the SA 5+6 autumn survey catch rate is assumed to reflect biomass at the end of the fishing season (Dawe and Hendrickson 1998).

Comparison of the July survey-based relative fishing mortality with SA 5+6 fall survey catch rate suggests that the fishery in SA 3+4 does not adversely affect the resource in SA 5+6 (Fig. 4a). Fall survey catch rates in SA 5+6 not only remained high throughout the 1978-80 period of highest relative exploitation in SA 3+4, but peaked immediately afterward, in 1981.

The relative fishing mortality series based on the September SA 4 survey suggests that relative exploitation in SA 3+4 was not high during the fishery peak of 1978-80 (Fig. 4b). Relative exploitation, based on this series, peaked in 1973, two years before the SA 5+6 fall survey catch rate first increased substantially.

Since squid fisheries in all areas are believed to target a common stock, it is of interest from a conservation perspective to consider the effect of total fishery removals on relative fishing mortality for the entire stock. For this comparison it is assumed that the SA 5+6 fall survey kg/tow reflects annual total stock biomass, which is justified because that index is significantly positively correlated with other survey indices and with catch trends, particularly in Subareas 3 and 4 (Dawe and Hendrickson 1998). Annual relative fishing mortality for the total stock was calculated by dividing the total SA 3-6 landings by the SA 5+6 fall survey kg/tow (Fig. 5). It appears that overall fishing mortality was relatively low during the 1976-81 period of peak catch when most of the catch was derived from SA 3+4. Highest fishing mortality occurred in 1973, when 66% of the total catch was derived from SA 5+6 (Dawe and Hendrickson 1998).

It is interesting that the main peak of fishing mortality in 1973 was soon followed by a regular increase in catches during 1975-1979 (Fig. 5), which corresponded to a warm oceanographic regime (Dawe et al. 1998). In contrast, a secondary peak in relative fishing mortality during 1982-1983 coincided with the onset of a prolonged period of low biomass and cold oceanographic regime. While low total stock biomass since 1983 has been related to the environment (Dawe et al. 1998), the possibility that high fishing mortality was a contributing factor cannot be dismissed.

Comparison with Other Squid Species

The most appropriate species for comparison with I. illecebrosus is probably the Japanese common squid (Todarodes pacificus), another ommastrephid squid which inhabits a western boundary current system; the Kuroshio. It's life cycle is remarkably similar to that of Illex illecebrosus, with several seasonal spawning groups, of which the winter-spawning group is usually dominant and most variable, especially in fishery areas most distant from the spawning area (Hatanaka et al. 1985).

The fishery for Japanese common squid declined sharply after 1968 (Fig. 6a), especially in the most northern area off the Pacific Coast of Japan, but also later in the Sea of Japan. Catches did not begin to increase again until the late 1980's (Fig. 6a). Murata (1980) postulated that the collapse of that fishery was due to overfishing, during a period of natural stock decline.

Although the effect of relatively high fishing mortality during the early 1980's remains unknown, it appears that the high catches during the late 1970's were not excessive. Catches in fisheries for some other ommastrephid squids have reached much higher levels (Fig. 6b). The fishery for T. pacificus peaked in 1968 at about 668,000 t, 270 % higher than the 1979 peak catch of I. illecebrosus. The catch of con-generic I. argentinus increased to about 330,000 t in 1993, 84 % higher than the peak I. illecebrosus catch.

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Table 1. Comparison of late-season size between SA 3 and SA 5+6.Modal size for SA 3 is derived from samples from the inshore Nfld. jig fishery (Ennis and Collins 1978), whereas that for SA 5+6 represent the largest mode from bottom trawl surveys (Mesnil et al 1976, Mesnil 1977).

Year	Area	Date	Modal Length, cm	
			Male	Female
1975	SA 3	Oct 29	24.5	26.5
	SA 5+6	Nov 22-Dec 15	23	26
1976	SA 3	Nov 3	22.5	25
	SA 5+6	Oct 28-Dec 6	22.8	27

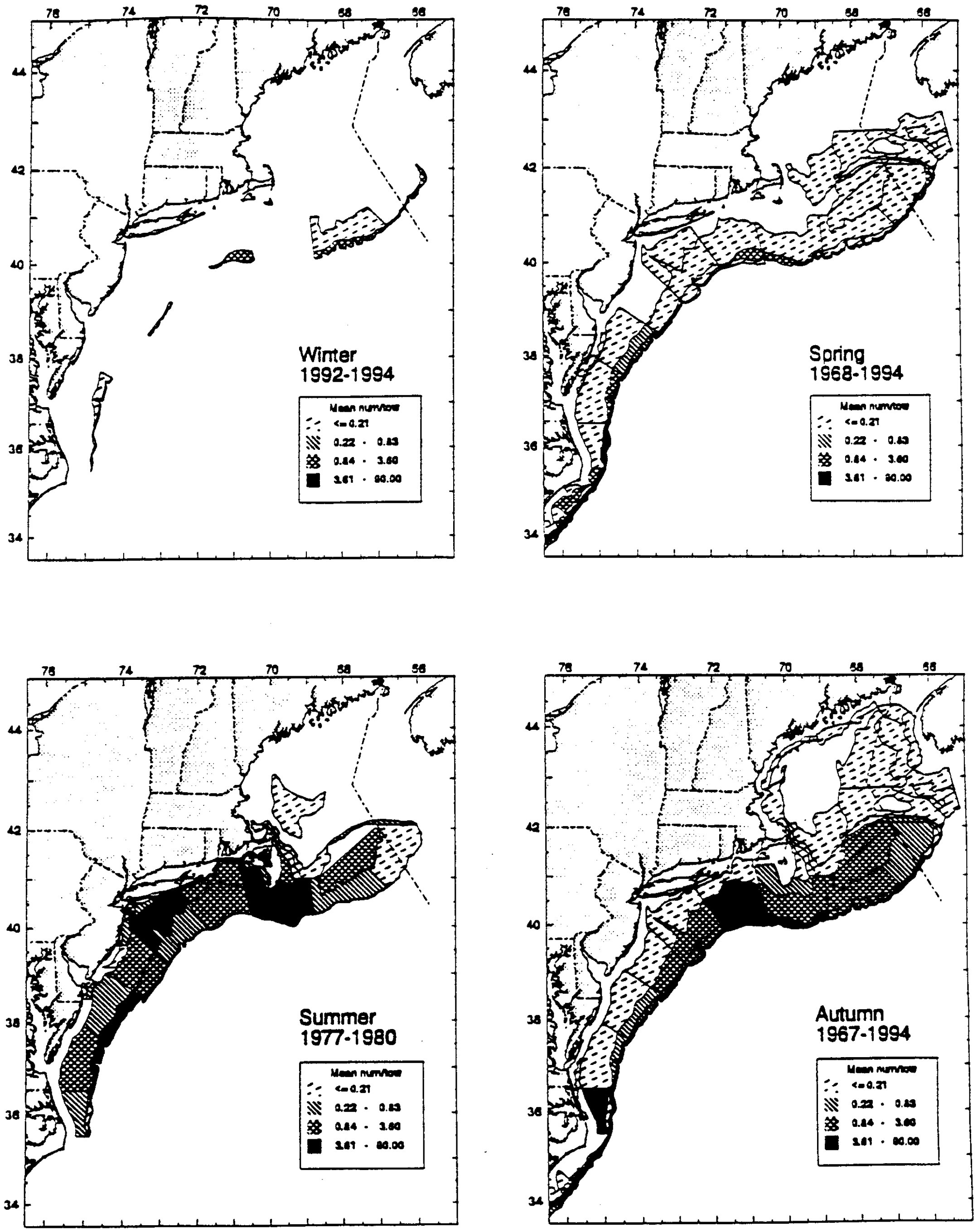

Fig. 1. Mean number per tow of Illex illecebrosus pre-recruits (10 cm and smaller), by survey stratum, during NEFSC research vessel bottom trawl surveys (from Dawe and Hendrickson 1998).

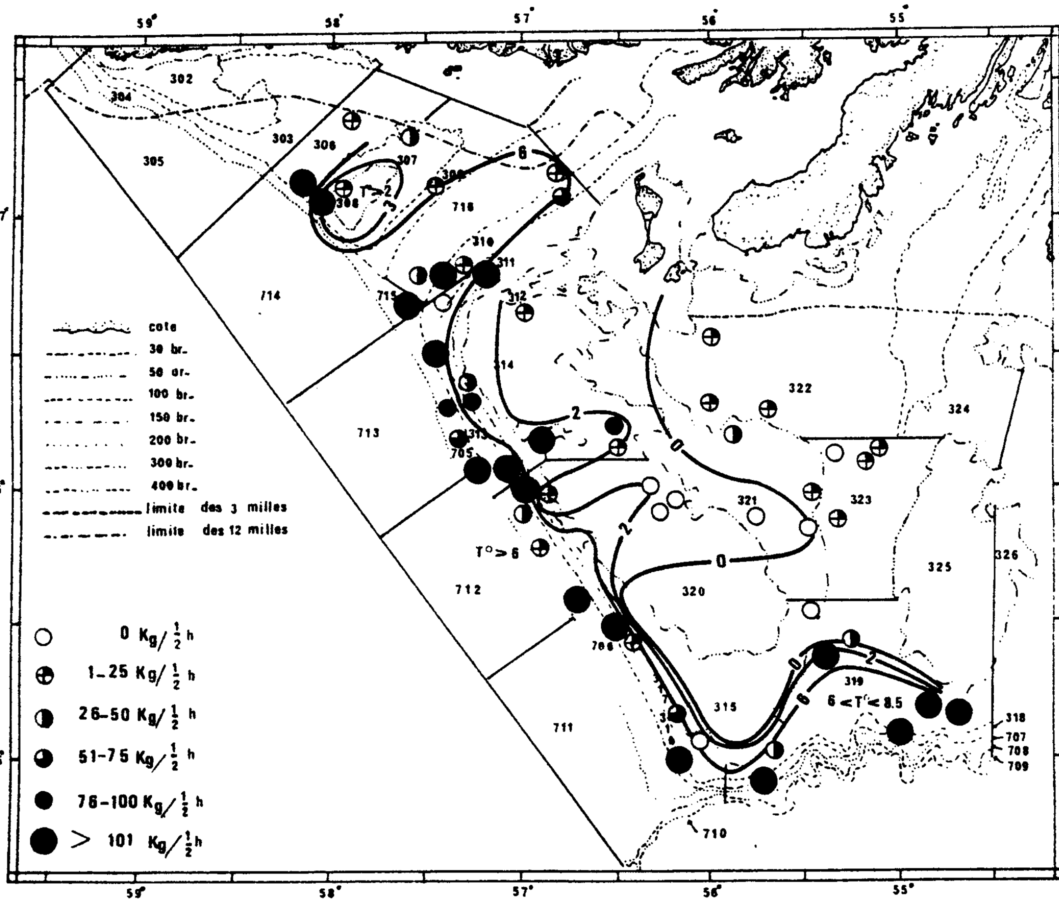

Fig. 2. Distribution of short-finned squid in relation to bottom temperature isotherms during an Oct. 12-31, 1979 bottom trawl survey on St. Pierre Bank, NAFO Subdivision 3Ps (from Dupouy and Poulard 1980).

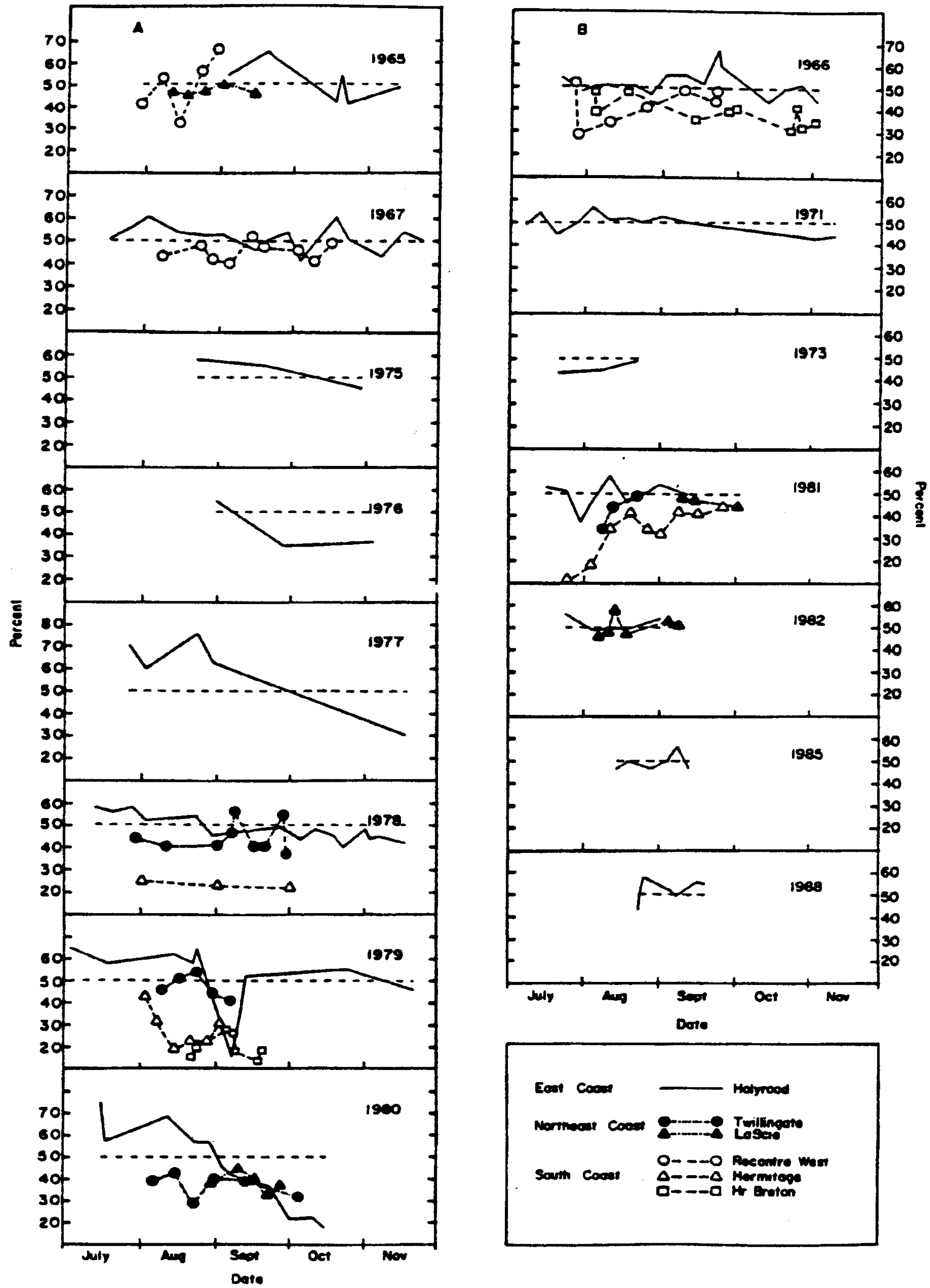

Fig. 3. Seasonal trends in percentage of males within commercial squid samples from inshore Newfoundland sampling sites during some years of high inshore abundance (A) and of low inshore abundance (B) (from O'Dor and Dawe 1998).

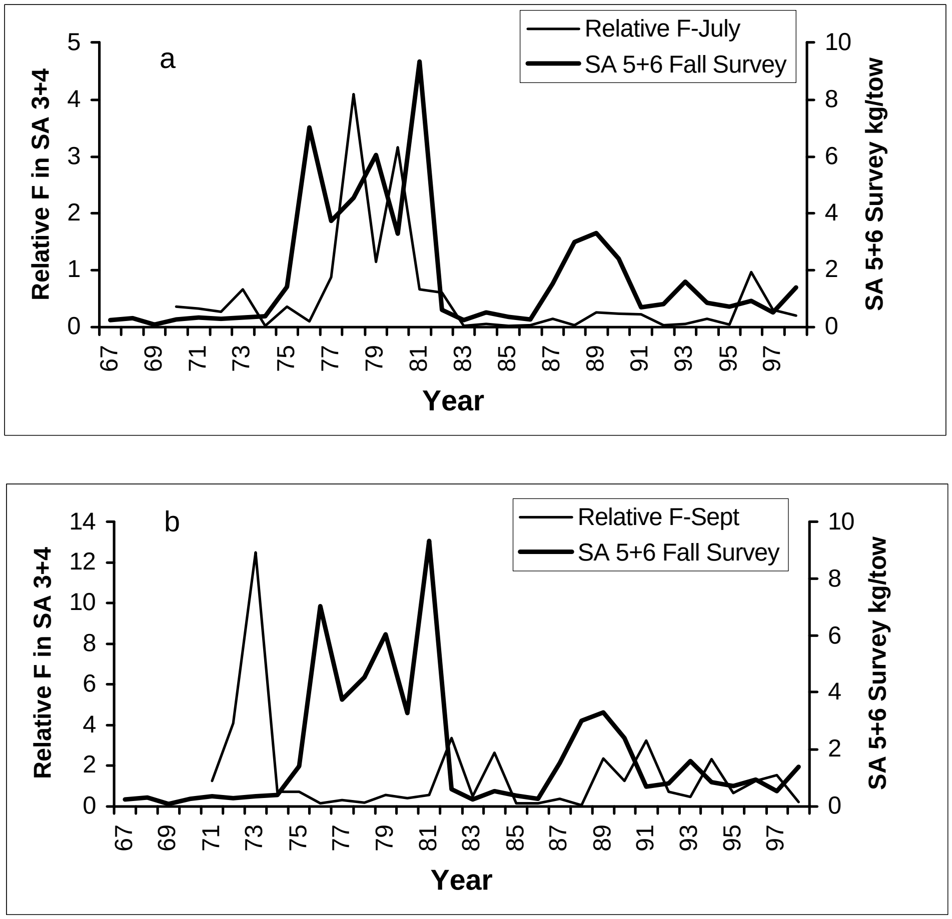

Fig. 4. Comparison of SA 5+6 fall survey catch rate with estimates of relative fishing mortality in SA 3+4, which utilized the SA 4 July survey kg/tow (a) and the SA 4 Sept. survey no/tow (b) as indices of yearly biomass level.

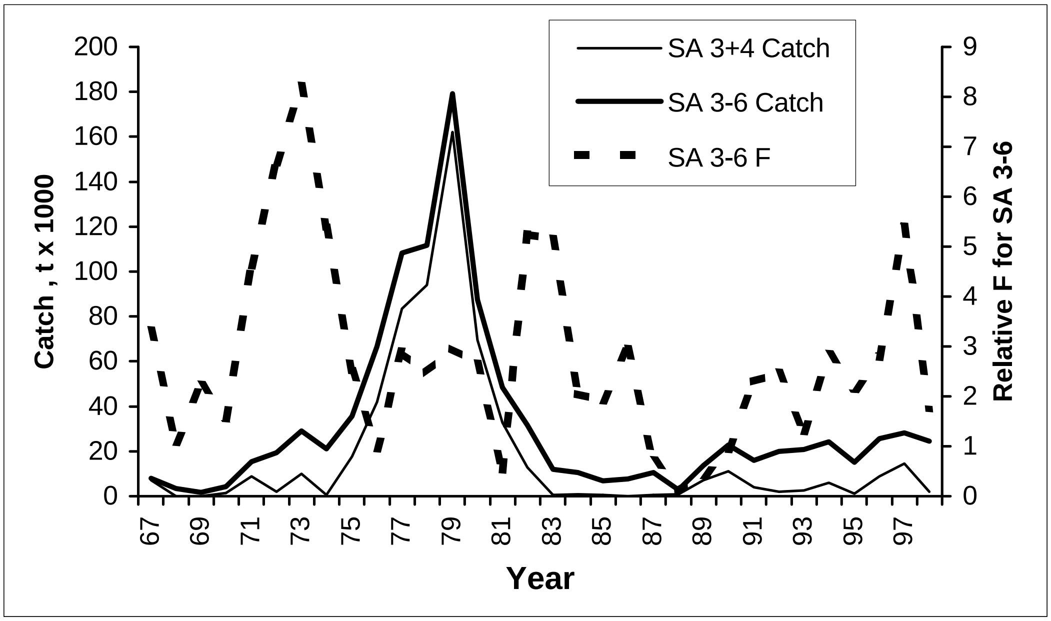

Fig. 5. Comparison of annual SA 3+4 catch and total SA 3-6 catch with relative fishing mortality for the total SA 3-6 stock.

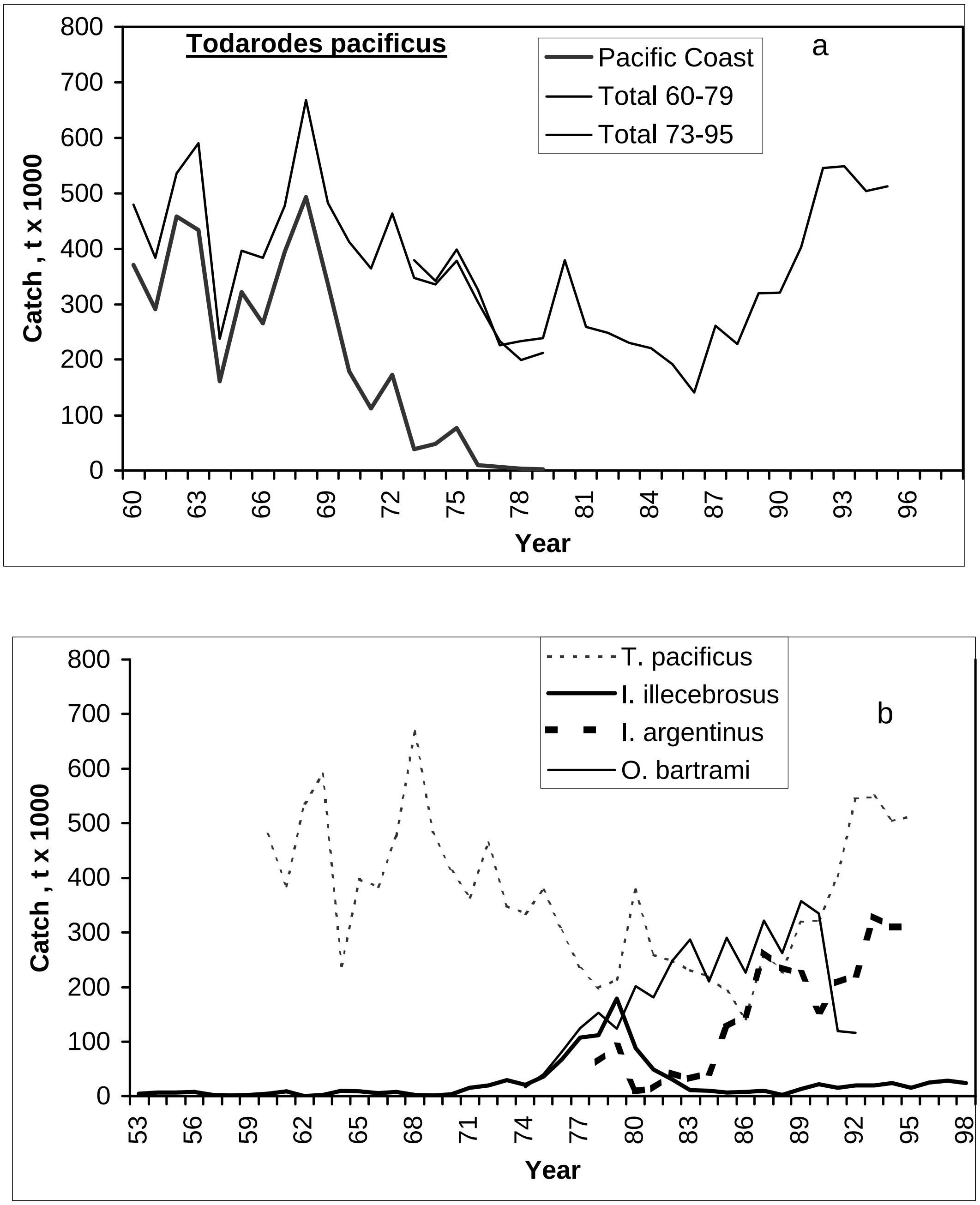

Fig. 6. Trends in annual catch for Japanese common squid from the North Pacific and for the total population (a) and for four species of ommastrephid squids, including Illex illecebrosus (b).