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Some Aspects of the Biology of White Hake, *Urophycis tenuis*, in the Southern Gulf of St. Lawrence

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Abstract

Various aspects of the biology of white hake in the southern Gulf of St. Lawrence were investigated from commercial and research survey data collected between 1965 and 1978. Nominal catches have generally declined from an annual average of 5,400 metric tons in 1960-69 to 4,800 tons in 1970-78. Length compositions of white hake landed by otter trawlers indicate a higher proportion of larger fish in the mid- 1970's than in the mid-1960's, the difference probably being due to a change in fishing practices. There was no difference in the length-weight relationships of males and females, but males attained sexual maturity at smaller sizes than did females. Comparable length-at-age data for Div. 4T and 4X show considerably faster growth in Div. 4X, indicating that growth may be inversely related to temperature. Limited observations on fecundity indicate that white hake may be among the most fecund on the commercially- exploited fishes in the Northwest Atlantic.

Introduction

White hake, *Urophycis tenuis* Mitchell, is a demersal gadoid, restricted in distribution to the western Atlantic Ocean from Newfoundland to Cape Hatteras (Leim and Scott, 1966) and exploited mainly in ICNAF Subareas 3 and 4, a significant portion of the Subarea 4 catch being taken in the southern Gulf of St. Lawrence (Division 4T) (Fig. 1). Little is known about the life history of white hake except for the generalized accounts of Bigelow and Schroeder (1953) and Leim and Scott (1966). However, Petrov (1973) reported on maturity, age composition and feeding of white hake in Subarea 3, and Nepszy (MS 1968) studied some biological aspects of the species in Div. 4T. Kohler (1971), in a tagging study of white hake in the southern Gulf of St. Lawrence, concluded that there was little intermixing between the southern Gulf population and populations outside the Gulf. Some confusion has existed as to the species of *Urophycis* present in the Gulf of St. Lawrence, but Musick (1967), on the basis of morphological criteria, suggested that all hake caught in Div. 4T were *Urophycis tenuis*, the designation used in this analysis.

Unpublished results of groundfish trawl surveys conducted by Canadian research vessels indicate that white hake abundance in the southern Gulf of St. Lawrence is centered off the eastern end of Prince Edward Island. The fishery is primarily a directed fishery and is seasonal in nature, peaking in July to September and being virtually absent from December to April due to ice conditions. Over 80% of the catches are made by vessels less than 25 GRT (gross registered

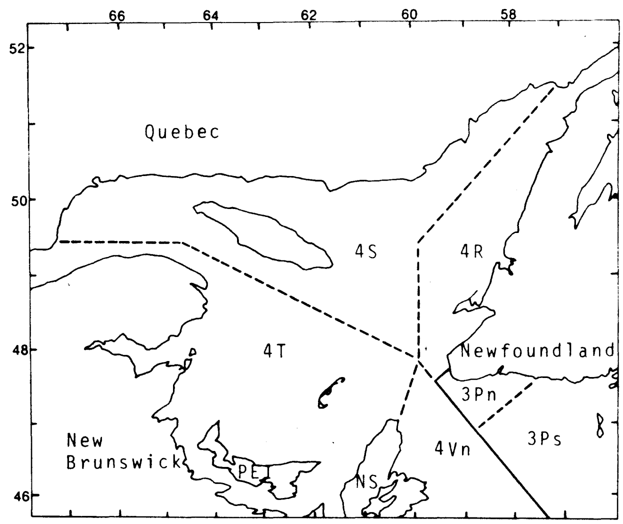

Fig. 1. Map showing the divisions of the Gulf of St. Lawrence.

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tons). As a prerequisite to a sound assessment of the fishery, this paper presents some aspects of the biology of white hake in the southern Gulf of St. Lawrence based on data collected from 1965 to 1978.

Materials and Methods

Length composition data for white hake in Div. 4T were derived from the sporadic sampling of commercial landings of Canadian otter trawlers, the most representative samples being those for the 1966-67 and 1976-77 periods. Data for length-weight and length-maturity analyses were derived from otter-trawl surveys by the research vessel *E. E. Prince* in 1970-78. The length measurement of white hake in the commercial and research samples was recorded as total length to the nearest cm and the total weight was recorded in grams. For the analysis of length at sexual maturity, a hake was defined as being mature if the gonads were in the ripening, ripe, spawning, spent or recovering condition.

The available growth data were derived from commercial samples collected in Div. 4T in 1965 and 1976. Some data for Div. 4X (southwestern Nova Scotia) in 1974 and 1976 are included for comparison. Otoliths were taken for age determination, but, due to the difficulty of ageing white hake and the absence of validation of ageing techniques, ages have been estimated for only a few samples. The otoliths were broken transversely, viewed under a binocular microscope, and the number of hyaline zones from the nucleus to the outer edge were counted as an indication of the age.

Fecundity estimates were made for 41 females collected in Div. 4T in 1966. After initial preservation of the ovaries in Gilson's fluid (Simpson, 1951), the eggs were cleaned by frequent spraying with water until free of ovarian tissue and the minute second-generation oocytes, spread thinly on absorbent paper to dry and subsequently weighed. Three subsamples of 1,000 eggs each were counted from the total egg mass, and the fecundity was estimated on the basis of the dried weights of the sample and the subsamples.

Results

Fishery trends

The nominal catches of white hake during 1960-78 in the southern Gulf of St. Lawrence relative to catches in Subarea 4 as a whole are shown in Fig. 2. Catches in Div. 4T have generally declined from an average of 5,400 tons annually in 1960-69 to 4,800 tons in 1970-78, the smallest catches being recorded in the mid-1970's. As a result of increased catches in other divisions of Subarea 4 during the early 1970's, the relative

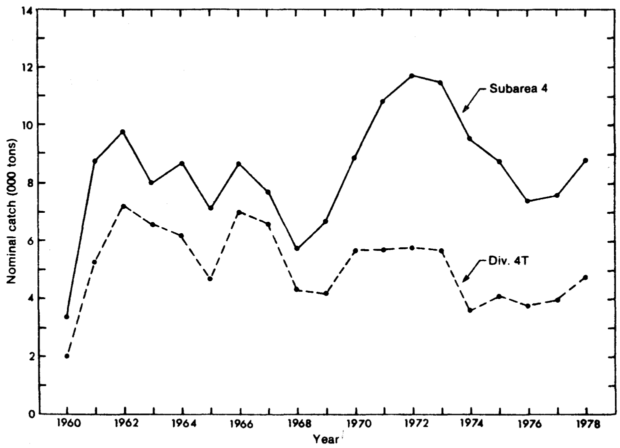

Fig. 2. Nominal catches of white hake in Div. 4T relative to those for Subarea 4, 1960-78.

proportion of white hake caught in Div. 4T declined from 72% during 1960-69 to about 50% during 1970-78. In the 1970's, gillnetters and other trawlers accounted for about 65% of the catches in Div. 4T, with Danish and Scottish seiners and inshore longliners each accounting for 10%, and the remaining 15% being attributed to miscellaneous or unknown gears.

Length composition

Typical length frequencies of white hake landed by Canadian otter trawlers are shown in Fig. 3. Most of the fish sampled ranged from 40 to 70 cm in length, the proportion greater than 70 cm being in the range of 10-15%. The number of fish less than 60 cm in length

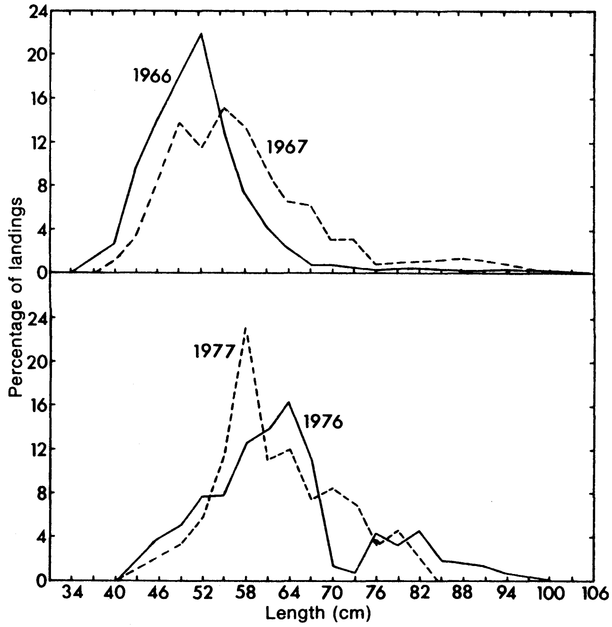

Fig. 3. Length compositions of white hake landed by Canadian otter trawlers from Div. 4T in 1966-67 and 1976-77.

was significantly greater in 1966 and 1967 than in 1976 and 1977 (χ^2 = 148, P<0.0001). However, the samples in 1966–67 were from the landings of otter trawlers over 50 GRT, whereas those in 1976–77 were from otter trawlers less than 50 GRT. The apparent difference in length compositions between 1966–67 and 1976–77 may not represent a real change in the size structure of the exploited population, as the length frequencies of white hake in the landings of otter trawlers less than 50 GRT in the mid-1960's, reported by Nepszy (MS 1968), were similar to those shown in Fig. 3 for 1976–77. The larger otter trawlers (>50 GRT) may take relatively greater numbers of small hake than the smaller trawlers, due perhaps to fishing in different areas or at different depths.

Length-weight relationship

The length-weight relationship for fish is generally described by the equation

$$W = aL^b \quad \text{or} \quad \ln W = \ln a + b \ln L$$

where W is the body weight (g) and L is the total length (cm). Functional regressions (Ricker, 1973), fitted to length and weight data for white hake obtained during research surveys in Div. 4T in September of 1970–77, produced the following relationships:

TABLE 1. Mean length-at-age data (cm) for white hake in Div. 4T and 4X, with linear regression parameters for ages 3 to 10 and Bertalanffy growth parameters for all ages sampled. (Numbers of specimens in parentheses.)

Age	Div. 4T		Div. 4X	
(yr)	1965	1976	1974	1976
3	54 (15)	41 (7)	40 (9)	42 (4)
4	55 (23)	46 (10)	46 (7)	46 (7)
5	59 (19)	53 (29)	51 (10)	51 (11)
6	67 (30)	57 (24)	58 (14)	64 (9)
7	80 (9)	62 (38)	72 (8)	72 (10)
8	84 (9)	66 (26)	80 (5)	76 (3)
9	93 (4)	69 (17)	82 (2)	82 (9)
10	98 (2)	76 (12)	92 (4)	92 (6)
No.	111	163	59	59
Slope	6.96	4.46	7.69	7.35
S. Error	0.50	0.36	0.43	0.40
Intercept	28.4	28.4	15.0	17.9
r^2	0.97	0.92	0.98	0.98
No.	137	172	60	68
L_∞ (cm)	113	105	194	140
K	0.27	0.11	0.06	0.10
t_0 (yr)	2.62	-1.52	-0.87	0.05

Male: $\ln W = 3.150 \ln L - 5.440$ ($r^2 = 0.99$, n = 875)

Female: $\ln W = 3.156 \ln L - 5.461$ ($r^2 = 0.99$, n = 815)

Unsexed: $\ln W = 3.153 \ln L - 5.451$ ($r^2 = 0.99$, n = 1614)

There was no significant difference between males and females with respect to increase in weight with length.

Growth

Mean length-at-age data for white hake in Div. 4T and 4X (Table 1) are based on the work of two readers, one having aged the 1965 samples and the other the 1974 and 1976 samples. Linear regressions of the length-at-age data were found to well represent the growth between ages 3 and 10, the coefficients of determination (r^2) being all greater than 0.90. Bertalanffy growth curves fitted to the mean length-at-age data over all age-groups sampled indicated that white hake in Div. 4X may grow to a larger maximum size than those in Div. 4T, but this result must be interpreted with caution. As indicated by the slopes of the regression lines (Table 1, Fig. 4), growth of white hake in Div. 4T may have been considerably faster in 1965 than in 1976, but this observation may be biased because the samples in the different periods were aged by different individuals. However, the 1974 and 1976 samples were aged by the same person, thus enabling a comparison of growth rates in Div. 4T and 4X in the mid-1970's. There was no significant difference in growth rates of white hake sampled in Div. 4X in 1974 and 1976 (Table 1), but these fish grew significantly

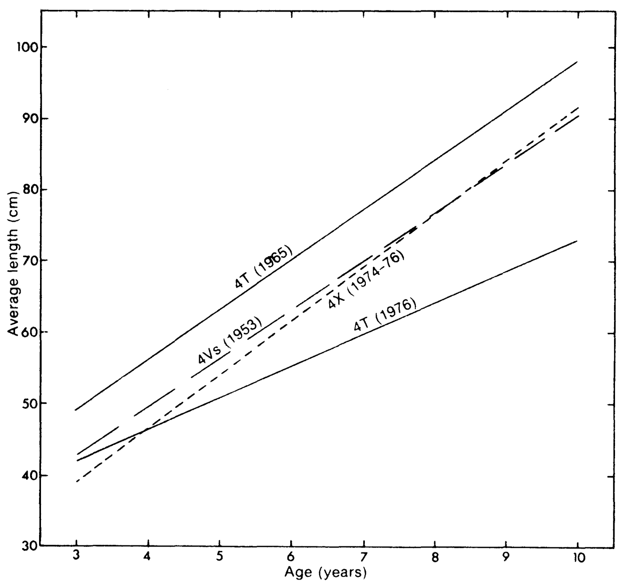

Fig. 4. Linear regressions of length on age for white hake age-groups 3 to 10 in Subarea 4. (Parameters of the regression lines are given in Table 1.)

faster than white hake from Div. 4T in 1976 ($t = 5.0$, $P < 0.001$). From the slopes of the regression lines over the range of ages 3–10, white hake in the mid-1970's grew about 65% faster per year in Div. 4X than in Div. 4T. However, the mean length-at-age values (Table 1) indicate that growth was similar up to age 5 but rapidly diverged at older age-groups. Mean length-at-age data reported by Rojo (1955) for white hake from Subdivision 4Vs in 1953 gave a regression line (slope = 6.80, intercept = 22.5 cm) not very different from that for Div. 4X in 1974–76 (Fig. 4), but this comparison may not be valid due possibly to different ageing techniques and the small number of fish (10) sampled.

Length at sexual maturity

The transition from immature to the mature condition in fish usually occurs over a range of length in the form of a sigmoid curve. From the percentages of mature white hake (ripening, spawning, spent or recovering condition) by 2-cm length intervals in samples from the September research vessel surveys in Div. 4T during 1971–78, the mean lengths (cm) at 50% maturity were calculated by probit analysis following the technique of Leslie *et al.* (1945). Males attained sexual maturity at smaller sizes than females, the difference being significant in most cases (Table 2, Fig. 5). The mean length at 50% maturity tended to decline until 1974 and to increase thereafter, the trend being more apparent in females than in males.

TABLE 2. Mean length (cm) at 50% maturity and sample size (n) for male and female white hake in Div. 4T, 1971–78.

	Male		Female	
Year	Mean	n	Mean	n
1971	44.1	82	50.6	84
1972	39.4	79	48.0	61
1973	42.0	125	53.9	75
1974	36.6	268	40.1	207
1975	39.0	124	43.5	126
1976	37.3	124	45.3	96
1977	39.4	97	44.3	107
1978	40.0	205	48.3	161

Fecundity

Battle (MS 1951) indicated that three sizes of eggs were present in the ovaries of white hake prior to spawning, but only those developing for imminent spawning were included in the estimation of fecundity. The fecundity-length relationship for fish is generally described by the equation

$$F = aL^b \quad \text{or} \quad \ln F = \ln a + b \ln L$$

where F is the number of eggs and L is the total length (cm). The log-log regression describing the fecundity

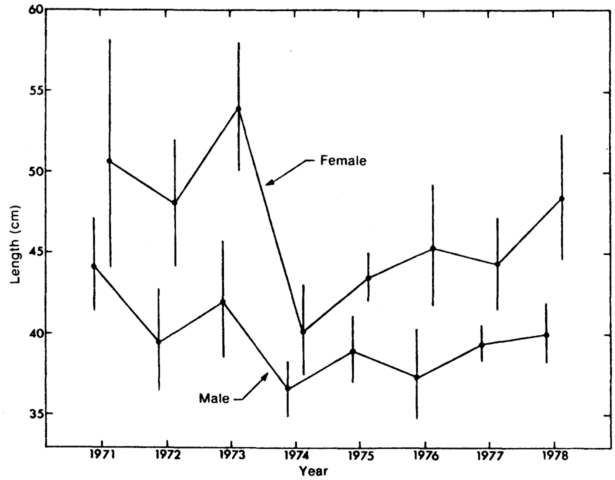

Fig. 5. Mean length at 50% maturity for male and female white hake in Div. 4T, 1971–78. (Vertical lines represent 95% confidence intervals. Sample sizes are given in Table 2.)

of 41 female white hake from Div. 4T in 1966 is

$$\ln F = 5.53 \ln L - 8.2663 \quad (r^2 = 0.74)$$

and the resulting fecundity-length curve is shown in Fig. 6. The regression coefficient (5.53) is somewhat larger than is usual for this kind of relationship, as most values for fish species generally lie between 3 and 5. Fecundity in white hake 70 to 80 cm in length tended to be more variable than at other sizes.

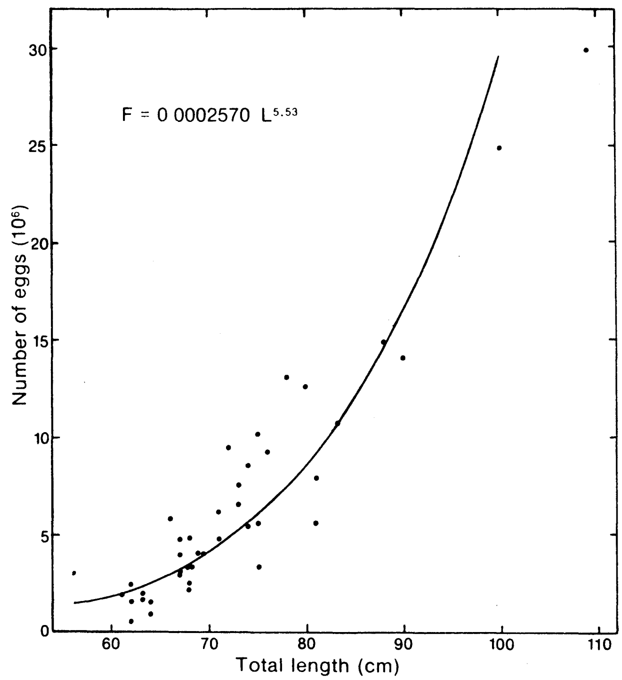

Fig. 6. Length-fecundity relationship for female white hake in Div. 4T from samples taken in 1966.

Discussion

Although there has been a directed trawl fishery for white hake in the southern Gulf of St. Lawrence for many years and substantial quantities are taken along the slopes of the Grand Bank and on the Scotian Shelf mainly as by-catches in fishing for other groundfish species, biological investigations have been rather limited. Kohler (1971), from a tagging study in the southern Gulf of St. Lawrence, concluded that the white hake population in the area constituted a unit stock, as only three of more than 600 recaptures of white hake tagged near the eastern end of Prince Edward Island occurred outside the Gulf on the Scotian Shelf. Further tagging studies at various locations in Subarea 4 are needed to elucidate migration patterns and delineate stock boundaries.

This study indicated that male white hake attained sexual maturity at smaller lengths than did females. Similar results have been reported for other gadoids such as cod (Powles, 1958; Fleming, 1960) and haddock (Templeman *et al.*, 1978; Templeman and Bishop, 1979). If male and female white hake grow at similar rates, males must necessarily mature at younger ages than do females. However, there is no evidence at present to evaluate this assumption, because the samples from the commercial landings used for ageing were not sexed and the samples available from the research vessel surveys have not yet been aged.

In a study on sexual maturity of haddock on the Grand Bank (Subarea 3), Templeman *et al.* (1978) attributed the decline in mean length at 50% maturity from 1951 to 1960 to declining growth associated with increased abundance, and the increase in mean length at 50% maturity during 1961-66 to increasing growth associated with decreased abundance. It is possible that a similar phenomenon occurred in the Gulf of St. Lawrence with respect to variability in the mean length at 50% maturity of white hake during the 1970's (Fig. 5). Unpublished data from Canadian groundfish surveys in Div. 4T indicate that the biomass of white hake increased from 1971 to 1974 and declined from 1974 to 1977, thus suggesting an inverse relationship between mean length at sexual maturity and population biomass. If there is a direct relationship between growth and stock abundance, as indicated by Templeman *et al.* (1978) for haddock, the growth of white hake in Div. 4T may be inversely related to population biomass, but the available length-at-age data are insufficient to verify this point.

This study indicates that growth in white hake may be inversely related to latitude in view of the substantially higher growth rate in Div. 4X than in Div. 4T. Fleming (1960) reported a similar situation for Atlantic cod in the Newfoundland-Labrador area. In general, water temperature is inversely related to latitude and thus may affect growth rates of white hake. In view of the scarcity of information on growth of white hake and its possible relationship to population biomass, future research should include the establishment of ageing criteria and the validation of ageing techniques as prerequisites to the biological studies required for stock assessments.

The rate of change in fecundity with respect to length in white hake was found to be greater than that reported by Powles (1958) and May (1967) for Atlantic cod, *Gadus morhua*, by Oldham (1972) for cusk, *Brosme brosme*, by Pitt (1964) for American plaice, *Hippoglossoides platessoides*, and by Hodder (1963) for haddock *Melanogrammus aeglefinus*, but in the last case the actual fecundity (number of eggs) of white hake and haddock in the 55-65 cm length range was similar. Although the fecundity estimates in this study were based on relatively few specimens over 80 cm in length, white hake appears to be among the most fecund of the commercially-exploited groundfish species in the Northwest Atlantic.

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