ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XIV Fasc. 1-2 Szczecin 1984

Leszek Bruno PREŃSKI

Fish biology

RESEARCH ON CAPE HAKE, *MERLUCCIUS CAPENSIS* CASTELNAU, 1861 OFF THE NAMIBIA SHELF. I. AGE, GROWTH, AGE OF RECRUITMENT AND TOTAL MORTALITY

BADANIA NAD MORSZCZUKIEM PRZYLĄDKOWYM, *MERLUCCIUS CAPENSIS* CASTELNAU, 1861 Z REJONU SZELFU NAMIBII. I. WIEK, WZROST, WIEK UZUPEŁNIENIA I ŚMIERTELNOŚĆ CAŁKOWITA

Institute of Fisheries Oceanography
and Protection of Sea

The work gives an assessment of body length age composition of catches, growth rate of body length and body weight, dependence of body length and body weight, total mortality and length and age of recruitment.

INTRODUCTION

It is not easy to estimate the age of Cape hake inhabiting the South-East Atlantic due to difficulties in a correct interpretation of growth zones on otoliths. So far, the issue has been dealt with by Botha (1969 and 1971), Elwertowski and Piotrowski (1975), Kolender (1975), Mombeck (1970, 1971), Mac Pherson (1976a), Pozo (1976), Pshenichnii (1970, 1976), Pschenichnii and Pozo (1971), Pšeničnii and Assorov (1971).

The aim of the work presented is to supplement the existing knowledge on the subject by assessing the parameters of the Cape hake stock fished within the shelf waters and the continental slope off Namibia.

MATERIAL AND METHODS

Materials were collected during cruises to the Namibia waters (ICSEAF statistical area 1.5), on board trawlers „Apus" and „Sirius" in March, April and May 1977. Catches were effected with pelagic trawl 4 cm smallest codend mesh size at the depth range of 120 do 410 m with trawling speed of 4 to 5 knots.

The fish to be examined were collected at random, their total length measured to 2 cm with intermediate lengths being rounded down (according to the ICSEAF recommendations). A total of 21459 fishes were measured, some of which being analysed in detail. The analysis included body weight (to 1 g) otolith collection, and sex determination. Because of the difficulties in sexing immature individuals visually (Maier scale stages 1 and 2) this group is treated further as a separate category, „immature". The age of the hake examined was read on otoliths placed in vessels with water and observed in incident light a stereomicroscope. The age composition of analysed samples was proportionally converted to frequency distribution based on the mass measurements using length-age conversion tables. Table 1 gives the summary of analyses performed.

Table 1

Summary of analyses

Analysis	No. of individuals
Length measurement	21459
Weighing	1558
Age reading	1650
Sexing	1572

The growth rate of *M. capensis* was analysed on the basis of empirical data according to the von Bertalanffy growth equation:

$$L_t = L_\infty [1 - e^{-K(t-t_0)}] \quad (1)$$

where: L_t = fish length at age t, L_∞ = asymptotic length, e = basis of the natural logarithm, t_0 = the beginning of growth curve theoretical age at which the fish would have length O if they had grown according to the von Bertalanffy equation, K = a coefficient of catobolism.

L_∞ was assessed with the Ford-Walford method while t_0 and K were estimated according to the transformed von Bertalanffy equation (Gulland, 1969):

$$1_n(L_\infty - L_t) = 1_n L_\infty + Kt_0 - Kt;$$

This is a linear equation of y = a + bx type and its parameters are found with the least squares method.

The length – weight relationship was determined with the formula:

$$W = a L^b \quad (3)$$

where: W = fish body weight, L = total fish body length, a and b = coefficients estimated with the least squares method.

The weight growth rate of Cape hake was expressed by the von Bertalanffy equation in Gullands modification:

$$W_t = W_\infty [1 - e^{-K(t-t_0)}]^b \quad (4)$$

where: W_t = fish body weight at age t, W_∞ = fish body weight when body length equals L_∞, K, t_0, b – coefficients from the von Bertalanffy growth equation and from the formula expressing the body length – weight relationship.

The W_∞ body weight was obtained by replacing L with L_∞ in the formula (3). This method, theoretically, is not entirely correct because of different courses of length and weight growth curves. For this reason the weight growth rate was additionally estimated with another method, one based upon the direct determination of mean body weights for different age groups. Such a method is given by Beverton and Holt (1957). The first step is to find W_∞ by means of regressing $W_t^{1/3}$ on $W_t{+}1^{1/3}$. Next, by applying the equation:

$$\log (W_\infty^{1/3} - W_t^{1/3} = [\log (W_\infty^{1/3}) + Kt_0] - Kt; \quad (5)$$

where: W_∞ = asymptotic weight, W_t = fish weight at age t, K and t_0 = as before, we find the values of K and t_0 by the least squares method.

Age of recruitment – t_r, was calculated according to the transformed formula of von Bertalanffy:

$$t_r = \frac{1}{K} \ln \frac{L}{L_\infty - L_t} + t_0 \quad (6)$$

The total mortality, Z, was estimated with three methods:

a) from the catch curve by applying the regression of natural logarithms of abundances in each age group and time;

b) from the survival rate, S, according to the relationship $Z = -1n\,S$, where a mean survival rate was calculated according to Ricker (1975):

$$S = \frac{N_{t+1} + N_{t+2} + \ldots\ldots N_K}{N_t + N_{t+1} + \ldots\ldots N_{K-1}} \quad (7)$$

c) from the formula given by Gulland (1969):

$$Z = \frac{K(L_\infty - \bar{l})}{\bar{l} - l_c} \quad (8)$$

where: $\bar{l}$ = a mean length of fishes in catches, l_c = the length of the first capture, K,L = the von Bertalanffy equation parameters.

AGE OF THE EXPLOITED POPULATION

The method of age assessment applied in this work based upon the number of hyaline zones on otholits, is difficult. The main cause of trouble are wide differences in width of the first growth zone and the presence of a number of additional hyaline zones difficult to distinguish from the correct first hyaline zone. Similiar phenomena were observed by Botha (1971) in the Cape hake and Nichy (1969) in *Merluccius bilinearis*.

After Botha (1971), October 1 was adopted as the date of birth, as opposed to that generally accepted by other authors and ICSEAF recommending January 1 as the conventional date of fish birth. The opaque zone stops growing between June and August; the hyaline one is formed during spawning, which takes place usually between September and November.

Tabels 2, 3 and 4 present data on length and age distributions.
Figs. 1 and 2 show the age and length distribution for all the fish combined and separately for males and females.

As can be seen, the catches contain the fish aged 1 to 14, with a marked domination of the age group 3. This group forms a clear peak around 30–32 cm on length distribution curves (Fig. 1). From the curves it appears also that females are somewhat longer that males. A comparison of the data presented in this work with the observations made by Draganik (1977), Pozo (1976), Pshenichnii (1970) and Psenicnii and Assorov (1971) on

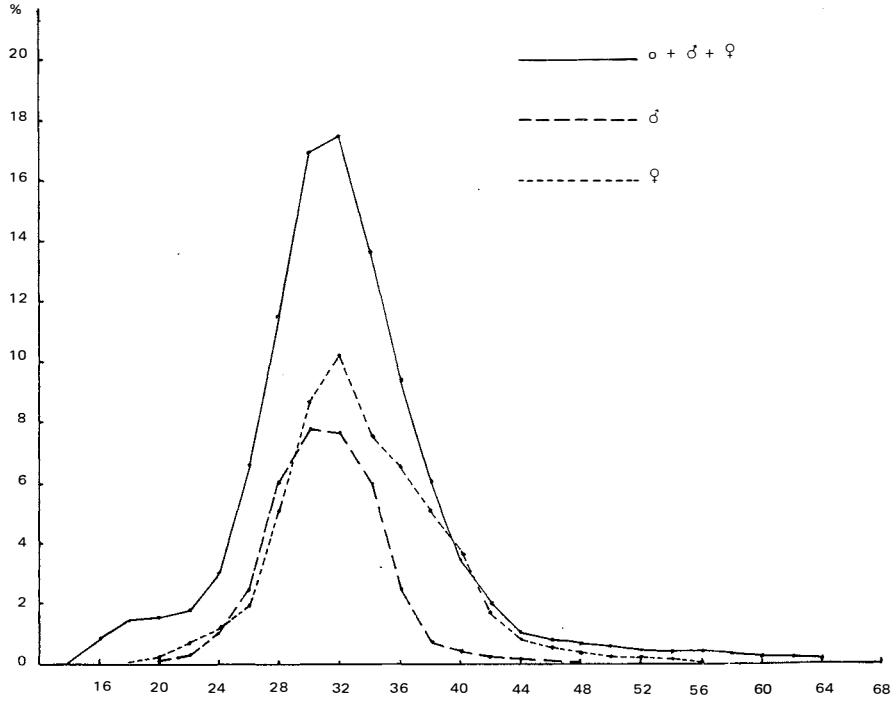


Fig. 1. Body length of hake caught within the ICSEAF area 1.5

Table 2

Summary of data on length and age of hake examined (o + ♂ + ♀)

Length	Age														No. of indiv. with age read	No. of indiv. measured
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV		
16	3														3	182
18	16	2													18	321
20	10	21													31	338
22	2	28													30	397
24		37	4												41	655
26		53	12												65	1410
28		39	58												97	2468
30		8	115	1											124	3652
32		1	147	5											153	3768
34			105	23											128	2930
36			49	57											106	2007
38			18	70											88	1277
40			1	79	2										82	724
42				81	6										87	449
44				34	25										59	225
46				19	33										52	161
48				7	30	4									41	115
50				1	32	7									40	96
52					30	10									40	56
54					23	7									30	48
56					13	14									27	30
58					8	23	4								35	24
60					1	20	3								24	20
62						19	7								26	12
64						15	15								30	14
66						7	19	1							27	17
68							20	6							26	10
70							17	6	3						26	6
72							5	11	4						20	16
74							3	12	3						18	5
76								7	8	2					17	8
78								3	1	2					6	5
80									4	6	1				11	7
82									1	2	2				5	2
84										6	7	2			15	1
86											4	3			7	1
88										1	2	4			7	2
90												2	1		3	–
92													3		3	–
94															–	–
96														2	2	–
No. of indiv. with age read	31	189	509	377	203	126	93	46	24	19	16	11	4	2	1650	–
No. of ind. measured	604	3609	12422	4111	498	120	43	21	12	8	5	1	–	–	–	21459

Table 3

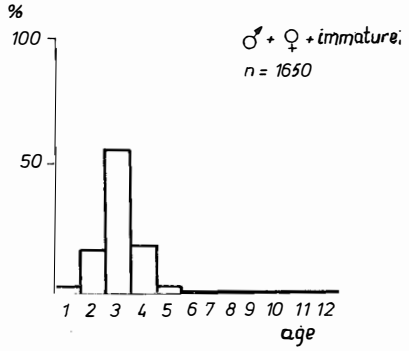
Summary of data on female length and age

Length	Age													No. of indiv. with age read	No. of indiv. measured
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV		
20	3													3	17
22	9													9	143
24	9	3												12	206
26	12	5												17	413
28	13	27												40	1101
30	3	58	1											62	1855
32		79	5											84	2208
34		51	14											65	1623
36		33	38											71	1425
38		15	56											71	1094
40		1	62	2										65	588
42			68	4										72	382
44			26	19										45	184
46			18	23										41	138
48			4	22	4									30	90
50			1	22	6									29	71
52				25	7									32	42
54				19	6									25	40
56				9	9									18	20
58				8	20	3								31	22
60				1	10	3								14	12
62					14	5								19	8
64					12	11								23	12
66					7	13	1							21	14
68						16	6							22	8
70						17	6	2						25	6
72						2	10	4						16	13
74						3	12	2						17	5
76							5	6	1					12	6
78							3	1	1					5	4
80								4	4	1				9	6
82								1	1	2				4	2
84									6	7	2			15	1
86									–	4	3			7	1
88									1	2	4			7	2
90											2	1		3	–
92												3		3	–
94													–	–	–
96													2	2	–
No. of indiv. with age read	49	272	293	154	95	73	43	20	14	16	11	4	2	1046	–
No. of indiv. measured	1155	6781	3275	381	94	35	20	11	5	4	1	–	–	–	11762

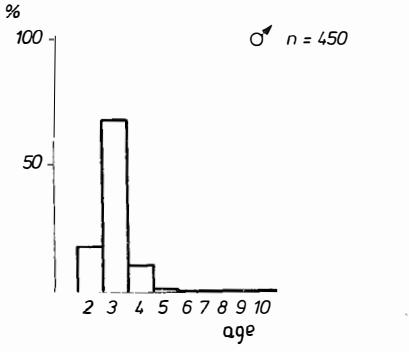
Table 4

Summary of data on male length and age

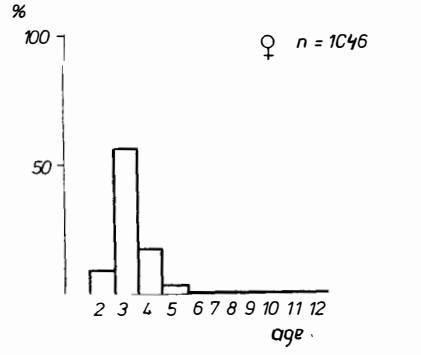
Length	Age									No. of indiv. with age read	No. of indiv. measured
	II	III	IV	V	VI	VII	VIII	IX	X		
20	1									1	13
22	5									5	63
24	15	1								16	244
26	26	7								33	759
28	20	30								50	1288
30	3	55								58	1676
32	1	64								65	1560
34		48	9							57	1283
36		14	16							30	542
38		2	9							11	152
40			14							14	127
42			9	1						10	61
44			7	3						10	41
46			1	6						7	23
48			3	5						8	25
50				9	1					10	25
52				5	2					7	9
54				4	1					5	8
56				3	5					8	10
58					2	1				3	2
60					9	–				9	8
62					5	2				7	4
64					2	4				6	2
66						5				5	3
68						3				3	2
70						–		1		1	–
72						2	1	–		3	3
74								1		1	–
76								2	1	3	2
78									1	1	1
80									2	2	1
82									1	1	–
No. of indiv. with age read	71	221	68	36	27	17	1	4	5	450	–
No. of indiv. measured	1535	5428	840	92	27	10	1	1	3		7937



yr	%
1 =	2.81
2 =	16.82
3 =	57.90
4 =	19.16
5 =	2.32
6 =	0.56
7 =	0.20
8 =	0.10
9 =	0.05
10 =	0.04
11 =	0.02
12 =	0.01



yr	%
2 =	19.34
3 =	68.39
4 =	10.58
5 =	1.16
6 =	0.34
7 =	0.13
8 =	0.01
9 =	0.01
10 =	0.04



yr	%
2 =	9.83
3 =	57.65
4 =	27.84
5 =	3.24
6 =	0.80
7 =	0.30
8 =	0.17
9 =	0.09
10 =	0.04
11 =	0.03
12 =	0.01

Fig. 2. Age composition of hake

the age of hake from ICSEAF area 1.5 indicates a considerable rejuvenation of the exploited stock. The number of individuals older than 5 years has decreased in the recent years, while age groups 2 to 4 have increased in abundance.

BODY LENGTH GROWTH

Growth rate studies are of basic importance for the estimation of resources of a given fish species. In the present work the growth rate of Cape hake *Merluccius capensis* was estimated mainly directly on the basis of a mean body length for each age group, considering also males and females separately (Table 5).
When comparing the empirical data with those reported by other authors, certain differences in length of various age groups can be seen (Table 6). These differences result probably from different times and location of catches.

The empirical data obtained for the hake growth were compared with theoretical ones calculated with the von Bertalanffy equation (Tab. 5, Fig. 3). As can be seen, a fast growth in length was typical of the younger age groups, the growth rate decreasing in older age. No significant differences in growth rate were noticed between males and females. The theoretical calculated data are close the empirical ones, which means that the von Bertalanffy equation is a correct description of the Cape hake length growth. The equation parameters calculated by the present author are given in Fig. 3 and Table 7. When compared with the parameters obtained by other authors, the largest difference appears between L_∞ in the present work and L_∞ obtained by Kolender (1975). However, Kolender's estimates included also mean lengths of the 1- and 2-yesrs-old individuals, while in the present work those age groups were disregarded, similarly to the procedure adopted by Draganik (1976a). Age readings for the first two years are not reliable as the first two annual rings are often difficult to be distinguished from the „pelagical ring" (Nichy, 1969). It appears from the data presented in Fig. 3 that the theoretical growth rate of females is slightly higher than that of males. The females attain a higher asymptotic length L_∞, while males show a somewhat higher coefficient of catabolism, K.

LENGTH-WEIGHT RELATIONSHIP

Relationship between the body length and weight of hake was assessed separately for immature individuals, males, and females. The equations describing that relationship and curves plotted are given in Fig. 4. The curves representing the length-weight relationship for males and females are almost identical.

Table 5

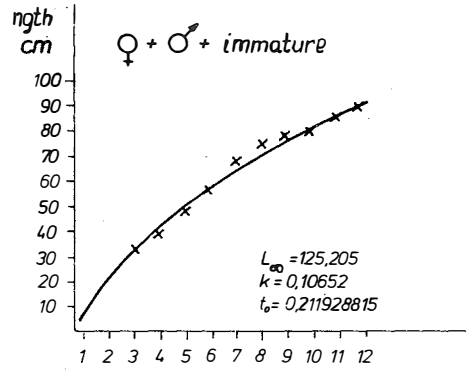
Mean length (cm) in age group

Item		Age group											
		1	2	3	4	5	6	7	8	9	10	11	12
♂ + ♀ and immature	Length from empirical data	18.7	24.9	32.6	38.8	48.6	56.9	67.2	73.7	76.1	80.2	85.0	89.0
	Length calculated from v. Bertalanffy equation	01.1	21.7	32.17	41.57	50.02	57.6	64.4	70.5	76.1	81.1	85.5	89.5
♀	Length from empirical data	–	27.2	32.9	39.0	48.6	56.3	66.8	73.9	77.0	81.0	86.0	89.0
	Length calculated from Bertalanffy equation	–	21.4	31.9	41.9	50.1	58.0	64.8	71.0	76.8	81.9	86.1	91.4
♂	Length from empirical data	–	26.8	32.3	38.2	48.1	58.0	67.2	73.0	77.0	79.0	–	–
	Length calculated from v. Bertalanffy equation	–	20.3	30.4	41.1	51.0	58.2	65.2	71.9	78.4	80.9	–	–

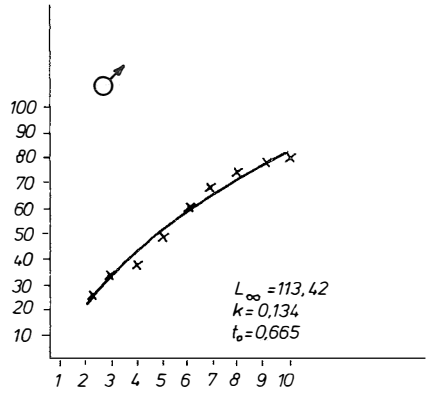
Table 6

Mean length (cm) in age group as calculated by various from empirical data

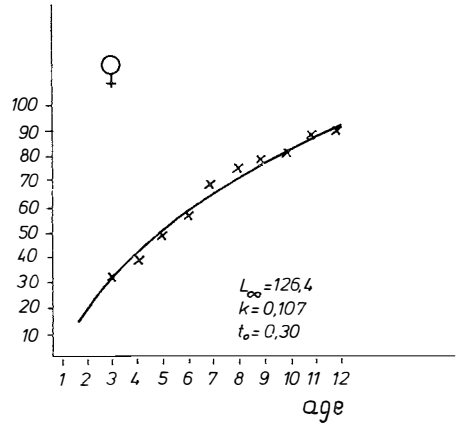
Age group	Mc Pherson (1976)	Kolender (1976)	Pozo Arteaga (1976)	Botha (1971)	Present data
1		16.17			18.9
2		25.25			26.6
3	41.47	34.18	35.15	29.82	32.6
4	49.10	42.33	43.84	37.48	38.8
5	54.71	50.19	52.31	46.79	48.6
6	58.96	57.54	56.89	55.81	56.9
7	64.46	64.45	65.85	62.70	67.2
8	72.66	70.75	70.40	73.05	73.7
9	82.70	76.19		78.40	76.1
10	84.00	84.42		79.76	80.2
11		90.20		86.78	85.0
12		96.43			89.0
13		99.50			
14		104.00			
15		110.00			



yr	terr.	Emp
1	10.08	18.7
2	21.7	24.9
3	32.17	32.6
4	41.57	38.8
5	50.02	48.6
6	57.6	56.9
7	64.4	67.2
8	70.58	73.7
9	76.1	76.1
10	81.08	80.2
11	85.52	85.0
12	89.53	89.0



yr	terr.	Emp
2	20.33	26.8
3	30.4	32.3
4	41.1	38.2
5	51.0	48.1
6	58.2	58.0
7	65.2	67.2
8	71.9	73.0
9	76.4	77.0
10	80.9	79.0



yr	terr	Emp
2	21.4	27.2
3	31.9	32.9
4	41.9	39.0
5	50.1	48.6
6	58.0	56.3
7	64.8	66.8
8	71.0	73.9
9	76.8	77.0
10	81.9	81.0
11	91.4	89.0

Fig. 3. The length growth rate of hake
Emp. – empirical values
teor. – theoretical values from von Bertalanffy growth equation

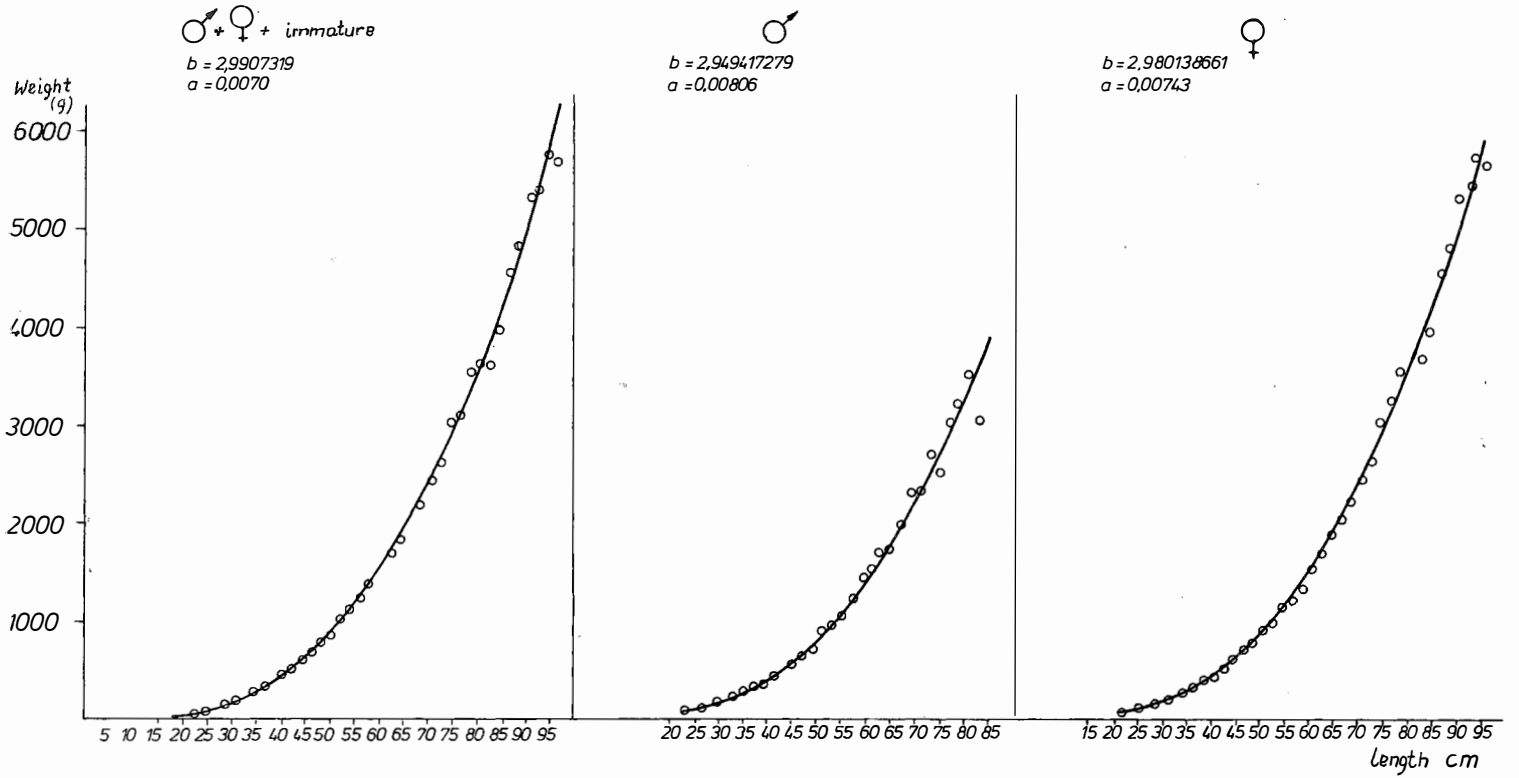


Fig. 4. Hake body length-weight relationship

Table 7

Hake growth parameters after various authors

ICSEAF area	L_∞ (cm)	K	t_0	Author
1.5 – 1.6	141.35	0.090	0.47	Botha (1971)
1.4	100.2	0.319	1.05	Mc Pherson (1975)
1.3 – 1.4	111.14	0.12	0.24	Pozo Arteaga (1976)
	174.83	0.0635	0.3653	Kolender (1975)
1.5	125.20	0.1065	0.2119	present study

BODY WEIGHT GROWTH

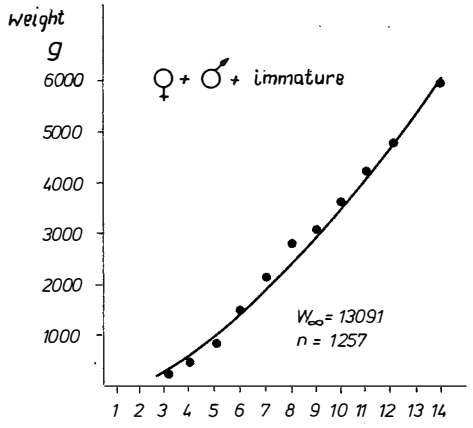
Table 8 gives the von Bertalanffy equation parameters for the body weight as calculated by two methods described in detail in the „Material and methods". As can be seen both methods gave similiar results.

Fig. 5 presents the weight growth of hake males and females and mean weights of both sexes assessed theoretically and resulting from the empirical data. There are differences in the weight growth of males and females. The asymptotic weight of females is over 4 kg higher than that of males. Table 9 gives mean weights for each age group of *Merluccius capensis* and *Merluccius paradoxus* recorded in studies made in various countries. Some

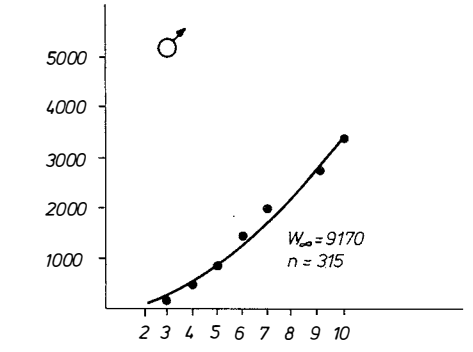
Table 8

Parameters of v. Bertalanffy equation for weight growth as estimated with two methods

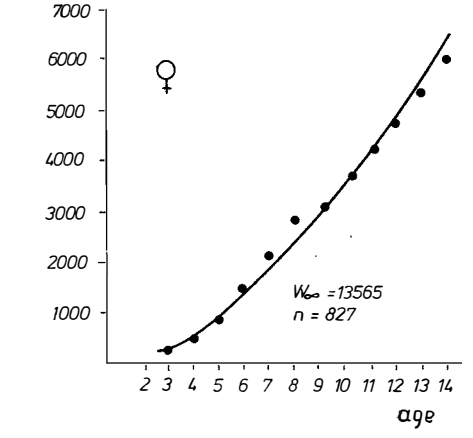
Growth parameters	V. Bertalanffy-Gulland method	Direct weighings in age groups
W_∞	13.918 kg	12.263 kg
K	0.10652	0.1143
t_0	0.2129 yr	0.1977 yr
L_∞	125.20 cm	122.35 cm



yr	teoret.	Emp.
1	7.00	51.83
2	69.40	130.13
3	225.10	253.64
4	484.40	478.20
5	842.50	841.20
6	1285.70	1420.16
7	1797.20	2134.76
8	2359.20	2851.82
9	2954.70	3063.90
10	3568.80	3619.68
11	4188.57	4221.00
12	4803.40	4797.20
13	5405.05	5319.25
14	5986.90	5970.66



yr	teoret.	Emp
2	44.13	143.34
3	190.00	244.50
4	451.88	458.25
5	817.48	853.61
6	1264.02	1436.65
7	1766.34	1994.80
8	2301.00	
9	2848.00	2765.33
10	3391.73	3338.80



yr	teoret.	Emp
2	64.68	164.34
3	220.29	258.62
4	484.7	486.10
5	853.14	849.10
6	1311.66	1414.82
7	1842.37	2169.60
8	2426.30	2855.48
9	3046.23	3113.60
10	3685.67	3720.00
11	4331.23	4221.00
12	4971.77	4797.20
13	5598.41	5319.25
14	6204.38	5970.66

Fig. 5. The weight growth rate of hake. Emp.– empirical values, teor. – theoretical values from von Bertalanffy growth equation with parameters assessed by Bertalanffy-Gulland method

Table 9

Mean weights (g) of hake in various age groups as shown by catches of different countries (after Draganik, 1976 a)

Country	Age group													Species
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Japan	–	143	383	760	1264	1873	2571	3321	4170	4979	5777	6567	7484	*M. paradoxus*
South Africa	–	77	234	489	850	1306	1838	2434	3108	3798	4519	–	–	*M. paradoxus*
Spain	–	–	429	836	1111	1512	2276	2578	3906	4045	–	–	–	*M. capensis*
USSR	85	192	320	560	1076	1548	2577	3596	4523	–	–	–	–	*M. paradoxus*
Present study	52	130	253	478	841	1420	2134	2851	3064	3620	4221	4797	5319	*M. capensis*

differences resulting from a variety of fishing grounds visited, different gear, and sample size are evident.

AGE AT RECRUITMENT

The knowledge of a recruitment age, t_r, is essential for stock size estimates.

Individuals less than 17 cm in length were caught incidentally, and in small numbers, usually trapped in corners of trawl wing meshes. A herring trawl cod end (2a = 40 mm) was used when fishing. Presumably the trapping took place in the pelagic zone during trawl haul up, when the wing meshes tend to traighten, rather than at depths inhabited by the major fish concentrations. This hypothesis is supported by results obtained by Nichy (1969) who confirmed the presence of silver hake *M. bilinearis* fry in the pelagic water. For this reason, too, those individuals smaller than 16 cm cannot be treated as a members of the exploited stock. Recruitment starts probably at 17 cm, i.e., when those fish are caught in the cod end with the larger individuals.

Recruitment ends at the peak of the frequency distribution, i.e., at the length of 33 cm. Assuming the S shape of the recruitment curve that begins at 17 cm we can accept the mean fish length at recruitment to be about 25 cm. Next the age when the exploited part of the stock was being supplied was estimated with the following coefficients:

$$L = 125.205 \text{ cm}, t_c = 0.2193 \text{ yr}, K = 0.1065.$$

The results were: $t_r = 2.31$ yr for $L_t = 25$ cm for the 40 cm cod end mesh size and $t_r = 3.97$ yr for 110 mm mesh size. Similar data for the age at recruitment are given by Draganik (1977).

TOTAL MORTALITY

Total mortality was calculated in three ways:

a) Mortality assessed from the catch curve

Owing to the lack of data on the abundance of various M.capensis age groups in catch per unit effort in subsequent years, the total mortality, Z, was calculated from the mean age distribution in catches. It was assumed that the mortality was similar in various age groups and that the frequency of each age group in catch was proportional to the corresponding frequency in the stock. Fig. 6 shows the relationship between the fish age and abundance in the exploited stock. The abscissa and ordinate represent age and logarithms of abundance in age group, respectively. The points obtained, when connected, form the catch curve, its descending part being close to a straight line. The slope of the line, found with the least squares method, is egual to $-Z$. Values of the coefficient refer to the fish from the age groups 3 and older. Table 10 gives the fishing mortality coefficients for males and females.

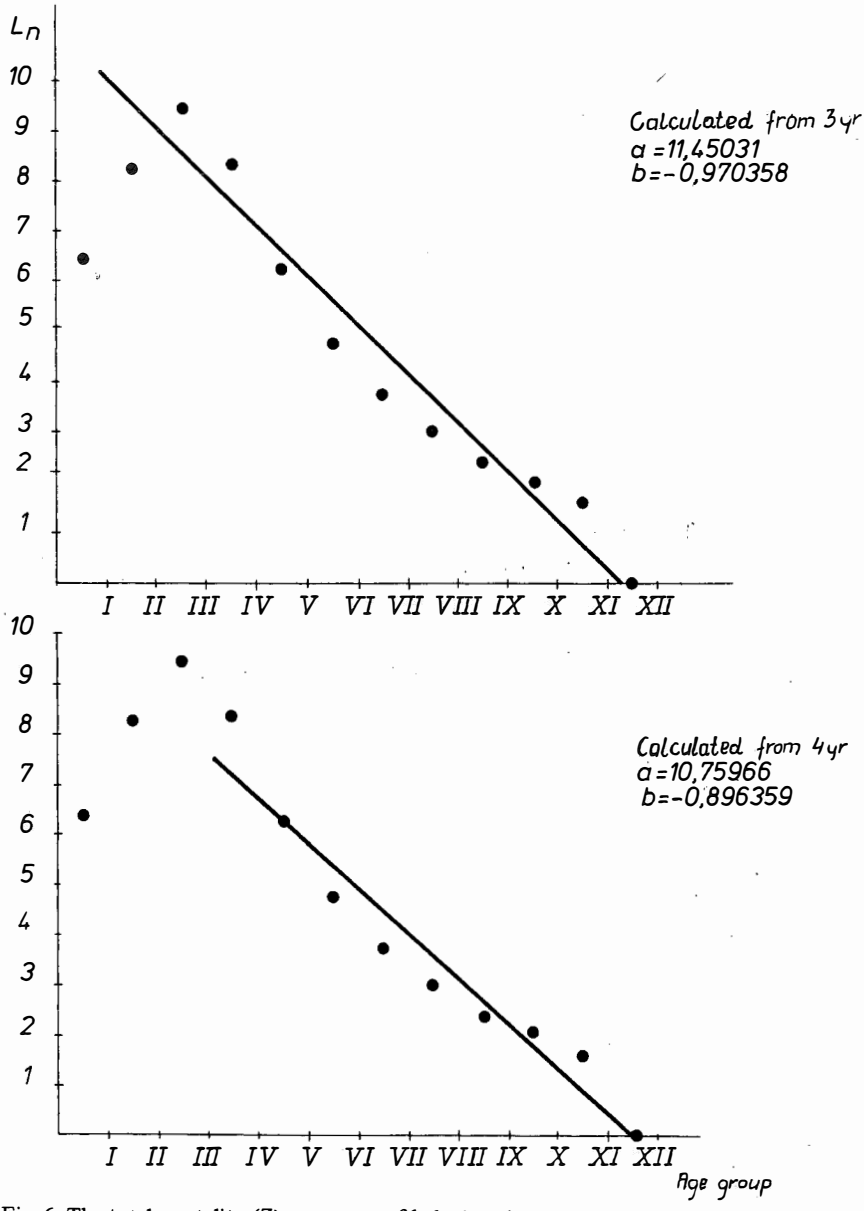


Fig. 6. The total mortality (Z) assesment of hake based upon the mean age frequency in catches

b) Mortality assessed from mean survival

The same assumptions as previously were adopted, the reults for males and females being given in Table 10.

c) Mortality assessed according to Gulland (1969)

When using this procedure it was assumed that the mean length of first capture was 24.4. cm. The results are shown in Table 10.

Table 10

Total mortality (Z) as estimated with different methods

Method	Calculated from 3 yr			Calculated from 4 yr		
	♀ + ♂	♀	♂	♀ + ♂	♀	♂
Mean age distribution	0.97	0.93	1.19	0.89	0.84	1.04
Mean survival	1.26	1.02	1.88	1.91	1.93	1.98
Formula: $Z = \frac{K(L_\infty - \bar{l})}{\bar{l} - l_c}$	1.17	1.00	1.60	1.17	1.00	1.60
Mean value	1.13			1.32		

SUMMARY

In March, April and May 1977 in the trawl-net catches of „Apus" and „Sirius" trawlers Cape hake of 16–88 cm in length were present (Fig. 1, Tab. 2,3,4). Age of hake was established by counting the hyaline rings on otoliths with 1st October as the date of fish „birth". The catches included the fish of age 1 to 12 with 3 years old fish as dominant. Cape hake has fast length growth rate over the first years of living which decrease when became older. The parameters of von Bertalanffy's equation are:

Females and males L_∞ = 125.20 cm; K = 0.1065; t_0 = 0.212 years
Males L_∞ = 113.42 cm; K = 0.1340; t_0 = 0.665 years
Females L_∞ = 126.40 cm; K = 0.1070; t_0 = 0.300 years

Almost identical curves were obtained to express the relations between weight and body length for males and females described with equations:

for males and inmature individuals jointly: $W = 0.0070\ L^{2.9907}$
for males $W = 0.0081\ L^{2.9494}$
for females $W = 0.0074\ L^{2.9801}$

An asymptotic weight of females (13.565 kg) is almost a 4 kg heavier than an asymptotic weight of males (9.170 kg). Total mortality was assessed by 3 methods. Its average value when starts from 3 year old fish was equal to 1.13 while with 4 years old fish amounted to 1.32. On the observation basis it can be said that the length at recruitment to exploited part of stock starts from 17 cm, for fish of that length appears in the cod-end. The recruitment ends at 33 cm. The average length at recruitment amounts to 25 cm which responds to the age at recruitment – 2.31 years.

REFERENCES

Beverton R.J.H., Holt S.J., 1957: On the dynamics of exploited Fish population. Ministry of Agriculture Fisheries and Food. Fisheries Investigation Series II Volume XIX.

Botha L., 1969: The growth of Cape hake. Merluccius capensis. Investl. Rep. Div. Sea Fish. S. Afr. 82: 1–9.

Botha L., 1971: Growth and otolith morphology of the Cape hakes. Merluccius capensis Cast. and M.paradoxus Franca. Investl. Rep. Div. Sea Fish S. Afr. 97: 1–32.

Draganik B., 1974: Hake stock exploited in the ICSEAF Convention Area (660) ICSEAF (w.6./74) Inf. Doc.(1).

Draganik B., 1976a: Fishing mortality of hake stocks exploited in subarea 1 of the ICSEAF Convention area. ICSEAF, coll. Sc. Pap. Vol. 3: 59–83.

Draganik B., 1976b: An attempt to apply Beverton and Holt's model in assessing the South African hake yield at different levels of fishing intensity. ICSEAF. Coll. Sc. Pap. Vol. 3: 85–90.

Draganik B., 1977: Equilibrium catch curves for hake fished in division 1-S ICSEAF 467 SAC/77/S.F../1.

Elwertowski J., Piotrowski A., 1975: An attempt to assess the parameters of hake stocks by means of computer programs. ICSEAF. Coll. Sc. Pap. N 2: 44–53.

Gulland J.A., 1969: Manual of methods for fish stock assessment. Part 1 Fish population analysis. FAO. Manual in Fisheries Science Nr 4 Frs/N 4 Rome.

Kolender E., 1975: Age and growth of hakes in the ICSEAF Area. ICSEAF Coll. Sc. Paper Vol. 2: 70–76.

Mc Pherson E., 1976: Crecimiento relativo de Merluccius capensis. ICSEAF Coll. Sc. Pap. Vol. 3: 115–119.

Mc Pherson E., 1976a: Datos Biologicos sobre Merluccius capensis en el primer trimestre de 1975. ICSEAF. Coll. Sc. Pap. Vol. 3:109–115.

Mombeck von F., 1970: Vorlaufiger Bericht ober Seehecht – Untersuchungen in SO Atlantik. Arch. Fisch. Wiss **21**, 1:45–61.

Mombeck von F., 1971: Weitere Mitteilungen über den Seehecht in südafrikanischen Raum. Arch. Fisch. Wiss **22**, 1:62–66.

Mombeck von F., 1971: 3. Mitteilung über den Seehecht in SO – Atlantik: Alter und Wachstum, Arch. Fisch. Wiss **22**, 3:34–40.

Nelson M.I., Larkin N.A., 1970: Distribution and biology of Pacific hake. U.S. Fish and Wildlife Service Circular FWC – A 332: 23–35.

Nichy F.F., 1969: Growth patterns of otholiths from young Silver hake. ICNAF Research Bulletin No 6.

Pozo Arteaga, 1976: Some data on the biology of the Cape hake (M. capensis) inhabiting the Cunene and Cape Cross Divisions of the ICSEAF area. ICSEAF Coll. Sc. Pap. No 3: 179–186.

Preński L.B., 1977: Studies on hake, Merluccius capensis in ICSEAF Divisions 1,4, and 1.5. in 1977. R 7A/SAC/77/S.P./12.

Pschenichnii B.P., 1970: K metodikie opredelenia wozrasta i tempa rosta merluzy jugo-zapadnej Afriki i Banki Agulias. Trudy WNIRO, **LXXI**: 210–219. (in Russian).

Pschenichnii B.P. , Pozo E., 1971: Some data on the growth rate of South African hake Merluccius merluccius capensis Castelnau. ICSEAF Coll. Sc. Pap. No 1: 220–233.

Pšeničnii B.P., Assorov W.W., 1971: Rost merluzy w rajone poberežia jugo-zapadnoj Afriki. Trudy ATLANT-NIRO , 41:43–52. (in Russian)

Pshenichnii B.P., 1976: On some changes in linear lenght of South African hake (Merluccius merluccius capensis Castelnau) ICSEAF Coll. Sc. Pap. No 3: 175–178.

Ricker W.E., 1975: Computation and Interpretation of Biological Statistics of fish populations, Department of the Environment fisheries and Marine Service. Bulletin 191, pp. 382. Ottawa.

Translated: Dr T. Radziejewska

Leszek Bruno Preński

BADANIA NAD MORSZCZUKIEM, *MERLUCCIUS CAPENSIS* CASTELNAU, 1861, Z REJONU SZELFU NAMIBII

I. Wiek, wzrost, wiek uzupełnienia i śmiertelność całkowita.

STRESZCZENIE

W połowach włokowych statków „Apus" i „Sirius" w marcu, kwietniu i maju 1977 r. występowały morszczuki o długości od 16 do 88 cm (rys. 1, tab. 2, 3, 4). Wiek morszczuka oznaczano licząc strefy szkliste na otolitach, za datę urodzin przyjmując dzień 1 października. W połowach występowały ryby w wieku 1–12 lat. Dominowały 3-latki. Morszczuk charakteryzuje się szybkimi przyrostami długości w pierwszych latach życia, malejącymi ze wzrostem wieku. Parametry równania wzrostowego von Bertalanffy wynoszą:

Samice i samce $L_\infty = 125{,}20$ cm; $K = 0{,}1065$; $t_0 = 0{,}212$ roku
Samce $L_\infty = 113{,}42$ cm; $K = 0{,}1340$; $t_0 = 0{,}665$ roku
Samice $L_\infty = 126{,}40$ cm; $K = 0{,}1070$; $t_0 = 0{,}300$ roku

Uzyskano niemal identyczne krzywe zależności masa-długość dla samców i samic, opisane równaniami:
dla samców, samic i osobników niedojrzałych łącznie:

$$W = 0{,}0070\, L^{2{,}9907}$$

dla samców: $W = 0{,}0081\, L^{2{,}9494}$
dla samic: $W = 0{,}0074\, L^{2{,}9801}$

Masa asymptotyczna samic (13,565 kg) jest niemal o 4 kg większa od masy asymptotycznej samców (9,170 kg). Śmiertelność całkowitą szacowano trzema metodami. Średnia jej wartość wyniosła przy ujmowaniu w szacunkach liczebności ryb od 3 roku życia, 1,13, zaś przy uwzględnianiu liczebności ryb od 4 roku życia 1,32. Z obserwacji wynika, że uzupełnienie eksploatowanej części stada zaczyna się od 17 cm, gdyż ryby od tej długości począwszy pojawiają się w worku włoka. Zakończenie uzupełnienia następuje przy długości 33 cm. Średnia długość uzupełnienia wynosi 25 cm, co odpowiada wiekowi uzupełnienia 2,31 roku.

Преньски Л.Б.

ИССЛЕДОВАНИЯ МЕРЛУЗЫ, MERLUCCIUS CAPENSIS CASTELNAU, 1861, ИЗ РАЙОНА ШЕЛЬФА НАМИБИИ. I Ч. ВОЗРАСТ, РОСТ, ВОЗРАСТ ДОПОЛНЕНИЯ И ПОЛНАЯ СМЕРТНОСТЬ

Р е з ю м е

В траловой рыболовли судов „Апус" и „Сириус", проведенной на протяжении марта, апреля и мая 1977 г., присутствовала мерлуза длиной с 16 до 88 см (рис.1, таб.2,3,4). Возраст мерлузы определяли на основании подсчёта стекловидных зон по отолитам, при установлении дня рождения на 1 сентября. Из уловов получено рыбу в возрасте 1-12 лет, но больше всего находилось особей в возрасте 3 года. Мерлуза отличается большими приростами длины в первые года жизни и уменьшением приростов длины с возрастом. Параметры для уравнения роста являются следующими:

самцы и самки $L = 125,20$ cm, $K = 0,1065$; $t_o = 0,212$ года
самцы $L = 113,42$ cm, $K = 0,1340$; $t_o = 0,665$ года
самки $L = 126,40$ cm, $K = 0,1070$; $t_o = 0,300$ года

Получено почти одинаковые кривые зависимости вес-длина для самцов и самок, представленные уравнениями:

для самцов, самок и несозревших особей совместно:

$$W = 0,0070\ L^{2,9907}$$

для самцов: $W = 0,0081\ L^{2,9494}$

для самок: $W = 0,0074\ L^{2,9801}$

Асимптотический вес самок (13,565 кг) почти на 4 кг больше асимптотического веса самцов (9,170 кг). Оценку полной смертности производили с помощью 3 методов. В среднем смертность составляла 1,13 - при учёте количества рыбы начиная с трёхлетнего возраста и 1,32 - при учёте количества начиная с четырёхлетнего возраста. Из проведенных наблюдений следует, что дополнение эксплуатационной части стада начинается с 17 см, так как рыба такой длины присутствует в мешке трала. Окончание дополнения происходит при длине 33 см. Длина дополнения в среднем составляет 25 см,что соответствует возрасту дополнения 2,31 года.

Author's address:
Dr. Leszek Bruno Preński
Instituto Nacional de Investigación
y Desarrollo Pesquero
Casilla de Correo 175
Playa Grande
7600 MAR del PLATA
Argentina

Received: 18 February 1983