ELSEVIER Fisheries Research 22 (1995) 309–318

FISHERIES RESEARCH

Short communication

Fecundity of whiting, *Merlangius merlangus euxinus* (L.) on the Turkish Black Sea coast

Ali Ismen*

Institute of Marine Sciences, Middle East Technical University, P.O. Box 28 33731, Erdemli-Icel, Turkey

Accepted 7 June 1994

Abstract

The fecundity of whiting from the Turkish Black Sea coast in 1990–1993 was highly correlated with length and to a lesser extent with age. For the western area, the fecundity–length relationship was $F=aL^{2.19}$ ($r=0.75$), and for the eastern area for the years between 1991 and 1993, $F=aL^{2.20}$ ($r=0.75$), $F=aL^{3.36}$ ($r=0.85$) and $F=aL^{2.74}$ ($r=0.80$), respectively. A significant difference in either fecundity–length relationship or fecundity–age relationship was seen between western and eastern areas. Annual variation in fecundity was not evident in the data for the years 1991–1993 from the eastern Turkish Black Sea coast.

Keywords: Merlangius merlangus; Reproduction; Turkey

1. Introduction

The Black Sea whiting (*Merlangius merlangus euxinus*) is a cold-water species that has adapted to life in the warm Black Sea. The range of preferred temperatures is 4–15 °C. The fish spawns throughout the year in the Black Sea, but spawning is at its height in the winter months. Unlike the Black Sea form, the whiting inhabiting the North, Baltic and Barents seas spawns in the summer. The whiting is a demersal fish and does not undertake long migrations. It moves to shallower depths in the spring (the upper boundary of distribution is at 15–30 m) and to greater depths (80–120 m) in autumn (Shulman, 1974).

There are few references to the fecundity of whiting in the literature. Kandler

* Corresponding author.

SSDI 0165-7836(94)00327-1

(1958) estimated the fecundity of 37 pre-spawning whiting from the Baltic, ranging in length from 25 to 39 cm. Their fecundity ranged between 108 000 and 221 000 eggs, and the relation between fecundity and length in cm (L) was expressed in the form Fecundity$=72000+2.404L^3$. Messtorff (1959) counted 120 400 and 1 151 000 eggs in 37 whiting, ranging in length from 23.5 to 38.5 cm, from the southern North Sea and reported a relationship between fecundity and length as Fecundity$=0.0065L^{5.28}$. He also noted a tendency for older whiting to be more fecund than younger ones at the same length. Hislop and Hall (1974) made fecundity estimations for whiting from the North Sea, the Minch and Iceland. For the Icelandic fish, they found a relationship between fecundity and length as Fecundity$=aL^{3.72}$. For all other samples the relationship was found to be Fecundity$=aL^{3.25}$. Hislop (1975) also gave the fecundity of whiting from the North Sea, ranging in length from 25 to 51 cm; it ranged from 170 000 to 2 089 000 eggs.

This paper presents the results of a fecundity study on Whiting on the Turkish Black Sea coast in relation to length and age, and compares the fecundity–length relationship for the western and eastern parts of the Black Sea.

2. Materials and methods

The ovaries used for fecundity estimation were collected from mature whiting taken by a deep trawl net aboard R/V 'Bilim' and R/V 'Surat 1' as follows: 115 specimens were collected in 1990 from the western Turkish Black Sea coast, 25 specimens were obtained in 1991, 47 in 1992, and 48 in 1993 from the eastern Turkish Black Sea coast. Total length measurements to the nearest centimetre and otoliths were obtained from all fish sampled for fecundity studies.

The ovaries were cut longitudinally and stored in Gilson's fluid. The ovaries were then treated as described by Hislop and Hall (1974) and Bagenal (1978) for counting. To separate the eggs from the connective tissue remnants, the eggs were placed in a graduated glass cylinder and water was added to make up a suspension of known volume. The suspension was agitated using a non-rotary action, until the eggs appeared to be distributed uniformly; a sample of known volume was then extracted with a pipette. All samples was counted several times under a binocular microscope and the mean value was calculated. The fecundity was estimated by multiplying the mean value by the factor V/v, where V is the volume of the suspension and v is the sample volume.

The data were grouped by geographical area, i.e. eastern (east of 35:00E) and western (west of 35:00E) Black Sea, and for analysis fitted by least squares regressions using log–log (base 10) transformations as described Hislop and Hall (1974). Analysis of covariance (Rohlf, 1986) was used to test the significance of the differences between regression coefficients and between the logarithms of the adjusted means. The sampling locations are shown in Fig. 1.

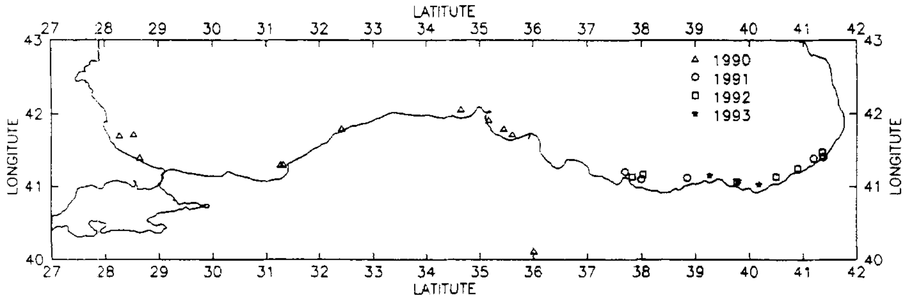

Fig. 1. Location of sampling stations along the Turkish Black Sea coast.

3. Results

3.1. Fecundity related to fish length

For the western Turkish Black Sea coast, analysis of data for 1990 indicated that fecundity is related to length by the relationship

$$\log F = 2.197 \log L + 2.182$$

where F is fecundity (number of eggs) and L is fish length (cm). For the eastern Turkish Black Sea coast, the relationships between fecundity and length for 1991, 1992 and 1993 are indicated by the respective equations:

$$\log F = 2.203 \log L + 2.421$$

$$\log F = 3.362 \log L + 0.801$$

$$\log F = 2.744 \log L + 1.585$$

Plots of fecundity–length data and the arithmetic forms of the relationship are shown in Fig. 2. In all cases the correlation coefficients (r) are significantly different from zero ($P<0.01$) (Table 1).

Analysis of covariance of the fecundity–length data for eastern Turkish Black Sea coast between 1991 and 1993 indicated no significance in either the regression coefficients (rate of egg production) or the adjusted means (quantity of eggs produced) except in 1991–1993 (Table 2). However, a similar analysis of fecundity–length relationship for the western Turkish Black Sea coast in 1990 and eastern parts between 1991 and 1993 indicated that the difference in regression coefficients is significant with $P<0.01$ and the difference in the adjusted means is highly significant with $P<0.01$ (Table 2).

3.2. Fecundity related to fish age

The fecundity–age relationship for the western Black Sea coast is indicated by the expression

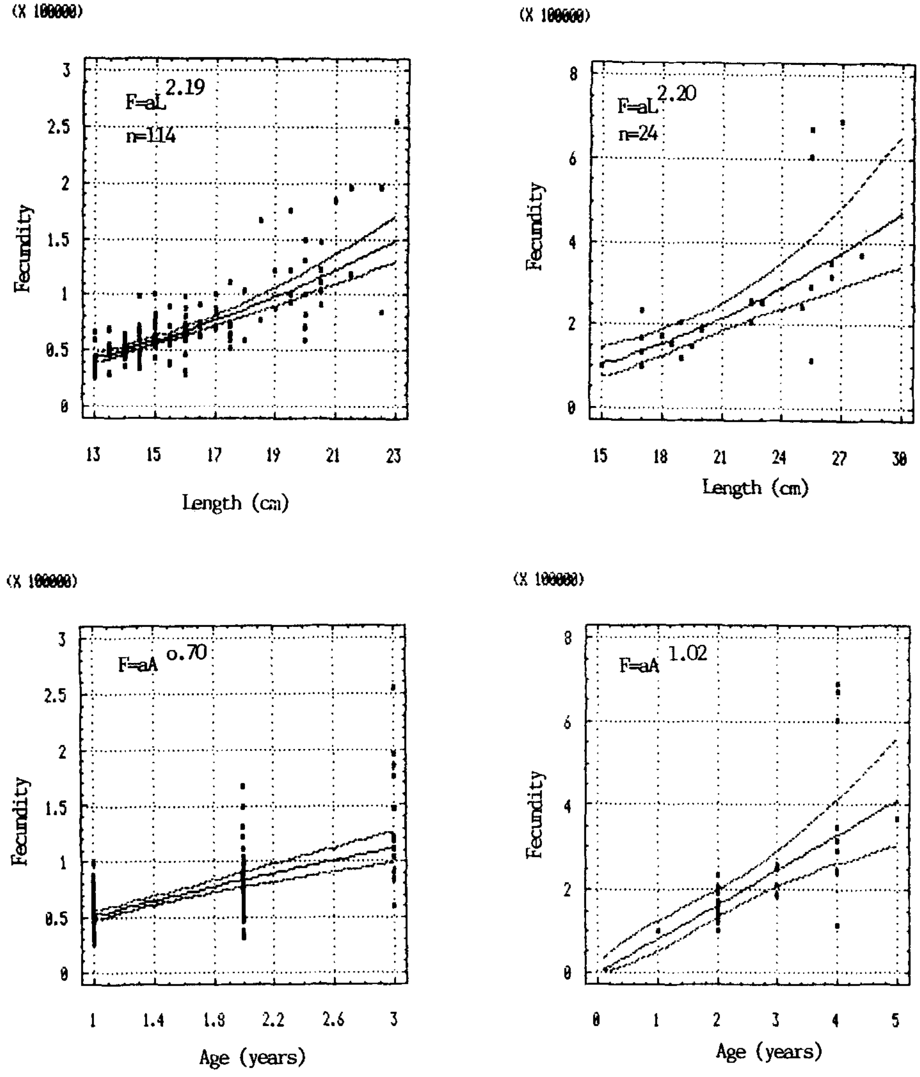

Fig. 2. Relationships of fecundity to length and age for whiting from the western Turkish Black Sea coast for 1990 (a), and from the eastern Turkish Black Sea coast for 1991 (b), 1992 (c) and 1993 (d).

$$\log F = 0.702 \log A + 4.713$$

and for the eastern Black Sea Coast in 1991, 1992 and 1993, respectively, by

$$\log F = 1.017 \log A + 4.905$$

$$\log F = 1.271 \log A + 4.691$$

$$\log F = 1.106 \log A + 4.729$$

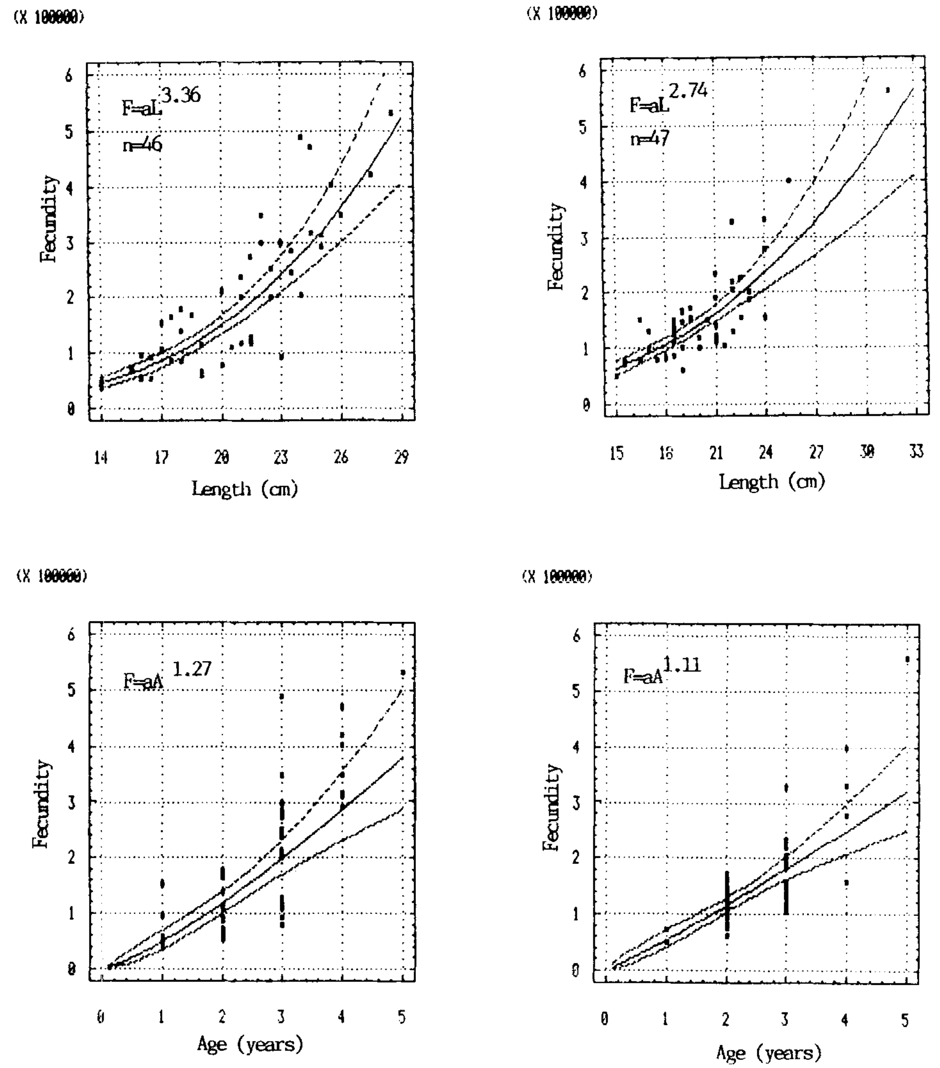

Fig. 2 (continued).

where A is fish age (years). Plots of the data and the arithmetic forms of the equations are shown in Fig. 2. The correlation coefficients (r) for all relationships are lower than those for the respective fecundity–length relationships (Table 1), but are still highly significant ($P<0.01$).

Analysis of covariance of the 1991, 1992 and 1993 fecundity–age data for eastern Turkish Black Sea coast indicated no significant difference between the regression coefficients and between adjusted means except in 1991 and 1993.

Table 1
Regression constants and tests of significance of correlations of fecundity with length and age for whiting from the western and eastern Turkish Black Sea coasts, 1990–1993

Area	No. of fish	Slope (b)	Intercept ($\log a$)	r
Fecundity–length				
Western Black Sea, 1990	115	2.197	2.182	0.75**
Eastern Black Sea, 1991	25	2.203	2.421	0.75**
Eastern Black Sea, 1992	47	3.362	0.801	0.85**
Eastern Black Sea, 1993	48	2.744	1.585	0.80**
Fecundity–age				
Western Black Sea, 1990	115	0.702	4.713	0.65**
Eastern Black Sea, 1991	25	1.017	4.905	0.72**
Eastern Black Sea, 1992	47	1.271	4.691	0.74**
Eastern Black Sea, 1993	48	1.106	4.729	0.73**

** Significant, $P<0.01$.

Table 2
Summary of covariance analyses for regressions of fecundity against length and age for whiting from western and eastern Turkish Black Sea coast

Area	Mean squares			
	Regression coefficients	F	Adjusted means	F
Fecundity–length				
Western Black Sea, 1990				
Eastern Black Sea, 1991–1993	0.159	7.752**	0.476	22.424**
Eastern Black Sea, 1991				
Eastern Black Sea, 1992	0.129	5.058	0.141	5.214
Eastern Black Sea, 1991				
Eastern Black Sea, 1993	0.240	1.235	0.247	12.618**
Eastern Black Sea, 1992				
Eastern Black Sea, 1993	0.040	1.909	0.011	0.527
Fecundity–age				
Western Black Sea, 1990				
Eastern Black Sea, 1991–1993	0.633	23.562**	1.174	39.804**
Eastern Black Sea, 1991				
Eastern Black Sea, 1992	0.042	1.262	0.181	5.407
Eastern Black Sea, 1991				
Eastern Black Sea, 1993	0.004	0.159	0.253	11.011**
Eastern Black Sea, 1992				
Eastern Black Sea, 1993	0.107	3.796	0.001	0.029

** Significant, $P<0.01$.

However, there were significant differences in these parameters for the western area in 1990 and the eastern area in 1991–1993 (Table 2).

3.3. Fecundity related to length and age

On the basis of the analyses presented above, fecundity in whiting appears to be related to both fish length and age. However, the lesser variation and higher correlation of fecundity–length data (Table 1) indicate that fecundity is more related to length than to age. A multiple correlation analysis was performed to determine the relative contributions of length and age to variation in fecundity (Table 3).

For the fecundity data from both of the geographical areas, the coefficients of determination for log-fecundity and log-length (r_{12}^2) are considerably greater than those for log-fecundity and log-age (r_{13}^2) (Table 3). However, when log-length and log-age are considered together in relation to log-fecundity, the coefficients of multiple determination ($r_{1\,23}^2$) for both areas are only slightly greater than the simple coefficients for log-fecundity and log-length (r_{12}^2). Analysis of multiple correlation indicated that the relative contributions of age to variation in fecundity are not significantly different from zero (Table 3). In conclusion, the variation in fecundity is adequately explained in terms of length alone.

4. Discussion

Fecundity in whiting from western and eastern Turkish Black Sea coasts was found to be related more to body length than to age. This conforms with results from earlier studies in the North Sea, Minch, Iceland and Northwest Atlantic on whiting (Hislop and Hall, 1974), and also on Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), witch flounder (*Glyptocephalus*

Table 3
Summary of statistics for multiple correlation of fecundity length and age for whiting

Parameters		Western parts	Eastern parts		
		1990	1991	1992	1993
Number of specimens	N	115	25	47	48
Coefficient of determination for X_1 and X_2	r_{12}^2	0.559	0.557	0.722	0.637
Coefficient of determination for X_1 and X_3	r_{13}^2	0.417	0.521	0.547	0.538
Coefficient of multiple determination	$r_{1\,23}^2$	0.559	0.558	0.727	0.637
Coefficient of partial determination	$r_{13\,2}^2$	0.005	0.105	0.009	0.100
F for $r_{13\,2}^2$		0.018	0.083	0.000	0.101

X_1 is log fecundity, X_2 is log length, X_3 is log age in estimating equation $X_1 = a_{1\,23} + b_{12\,3}X_2 + b_{13\,2}X_3$.

Table 4
Comparison of predicted number of eggs (thousands), at standard length (25 cm), with 95% confidence limits

Sea area	Year of sampling	Number of eggs (thousands) ($L=25$ cm)	
		Mean	95% limits
Northern North Sea	1964*	219	203–235
	1965*	227	212–243
	1966*	216	193–242
	1967*	207	191–223
	1969*	170	159–182
Southern North Sea	1966*	254	233–278
	1967*	240	219–263
Minch	1970*	175	159–191
Iceland	1968, 1969*	105	88–126
Western Black Sea	1990	179	169–189
Eastern Black Sea	1991	313	269–366
	1992	314	281–351
	1993	263	243–286

* Data taken from Hislop and Hall (1974).

Table 5
Comparison of mean length and age distributions for whiting estimated egg numbers from western and eastern Turkish Black Sea coast

	N	Mean length (cm)	Mean age (years)
Western parts			
1990	115	16.36 (13–24)	2
Eastern parts			
1991	25	21.54 (15–29)	3
1992	47	20.60 (14–29)	3
1993	48	20.19 (15–32)	3

Ranges are given in parentheses.

cynoglossus and Greenland halibut (*Reinhardtius hippoglossoides*) (Bowering, 1980).

Fecundity in fish of the same species has been reported to vary from one geographical area to another. Hislop and Hall (1974) stated that the fecundity level of the fish from Iceland differed from those in the North Sea and Minch. This was attributed to the difference of growth rates between different areas. Kjesbu (1988) found significant variation in the fecundity of Northeast Arctic cod and coastal cod from the region of northern Norway. Bowering (1980) found for Greenland halibut that the fecundity-length relationship from southern Labrador was significantly different from that for southeastern Gulf of St. Lawrence. The Greenland halibut differed in the rate of egg production and the number of eggs produced which Bowering (1980) attributed to maturing at considerably smaller sizes in the southeastern Gulf of St. Lawrence area. The present study shows that the fecundity level of the whiting from the Turkish Black Sea coast differs from those in the North Sea, Minch and Iceland. At the same length (e.g. 25 cm), the Black Sea whiting have a relatively high level of fecundity but the rate of increase in fecundity with length is slower (Table 4). This may be due to the variation in size at maturity as stated by Bowering (1980). The fecundity-length relationship for whiting from the western Turkish Black Sea coast is significantly different from that for eastern Turkish Black Sea coast. This may be due to dominance of small species in samples taken from the western areas in 1990 (Table 5).

Annual fluctuations in fecundity of whiting was not apparent in this study. Oosthuizen and Daan (1974) stated that the fecundity of cod in the North Sea was very similar in relation to years. Buzeta and Waiwood (1982) compared the fecundity in the cod from Gulf of St. Lawrence with data published about 25 years earlier and they too were unable to detect any significant change. Bowering (1980) also stated that annual fluctuation in fecundity was not apparent for the southern Labrador area in 1976 and 1977. However, such variation has been reported in many studies. Bagenal (1963), from a study in the Firth of Clyde, attributed annual fluctuation in the fecundity of witch flounder to changes in fishing intensity, which in turn affected fecundity through variation in the food supply. He also concluded that the variation in fecundity was not related to changes in hydrographic conditions. Pinhorn (1984) found annual variation in fecundity of Newfoundland cod. He attributed the observed variation to less feeding, slower digestion rate and increased atresia at low temperatures because of changing extreme cold water temperature.

Acknowledgements

I thank Prof. F. Bingel for comments, Prof. U. Unlüata (Director of the Institute of Marine Sciences-METU) for providing facilities, Y. Bekiroglu (Director) and technical staff of Fisheries Research Institute of Ministry of Agriculture in Trabzon for their help in collecting fish, and Erhan Mutlu for processing the data.

References

Bagenal, T.H., 1963. The fecundity of witches in the Firth of Clyde. J. Mar. Biol. Assoc. UK, 43: 401-407.

Bagenal, T.B., 1978. Fecundity. In: T.B. Bagenal (Editor), Methods for Assessment of Fish Production in Fresh Waters. IBP Handbook No. 3, 3rd edn. Blackwell Scientific, London, pp. 166-178.

Bowering, W.R., 1980. Fecundity of Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum), from Southern Labrador and Southeastern Gulf of St. Lawrence. J. Northwest. Atl. Fish. Sci., 1: 39-43.

Buzeta, M.-I. and Waiwood, K.G., 1982. Fecundity of Atlantic cod (*Gadus morhua*) in the southwestern Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aquat. Sci., 1110: 6 pp.
Hislop, J.R.G., 1975. The breeding and growth of whiting, *Merlangius merlangus* in captivity. J. Cons. Int. Explor. Mer, 36(2): 119-127.
Hislop, J.R.G. and Hall, W.B., 1974. The fecundity of whiting, *Merlangius merlangus* (L.) in the North Sea, the Minch and at Iceland. J. Cons. Int. Explor. Mer, 36(1): 42-49.
Kandler, R., 1958. Whiting, Baltic stock, German investigations. Ann. Biol. Copenh., 15: 123.
Kjesbu, O.S., 1988. Fecundity and maturity of cod (*Gadus morhua* L.) from Northern Norway. ICES, C.M. 1988/G:28.
Messtorff, J., 1959. Untersuchungen über die Biologie des Wittlings *Merlangius merlangus* in der Nordsee. Ber. Dtsch. Wiss. Komm. Meeresforsch., 15 (H.4): 277-334.
Oosthuizen, E. and Daan, N., 1974. Egg fecundity and maturity of North Sea cod, *Gadus morhua*. Neth. J. Sea Res., 8: 378-397.
Pinhorn, A.T., 1984. Temporal and spatial variation in fecundity of Atlantic cod (*Gadus morhua*) in Newfoundland waters. J. Northwest. Atl. Fish. Sci., 5: 161-170.
Rohlf, F.J., 1986. Biom. A Package of Statistical Programs to Accompany the Text Biometry. State University of New York, New York, 108 pp.
Shulman, G.E., 1974. Life Cycles of Fish; Physiology and Biochemistry. Wiley, New York, 258 pp.