Mercury in some fish of the North Levantine (Eastern Mediterranean)

by

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Abstract

From among the various species which migrate to the Levantine Sea via the Suez canal, two demersal fishes namely, Upeneus moluccensis and Saurida undosquamis, were selected and mercury distribution was determined in detail. The parameters measured were, age size, weight, time location and, whenever possible, sex. It was noted that these two fish of Indopacific origin behave different in some particular ways from native fish, e.g. U.moluccensis accumulates much more mercury than other members of the familly such as Mullus barbatus, while S.undosquamis, regulates mercury very efficiently.

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Introduction

We have reported previously (BALKAS, et al., 1979; TUNCEL et al., 1980; TURGUL, et al., 1980) and are continuing to study the distribution of mercury amongst fish resident in the Eastern Mediterranean. Relatively recently it was observed (DAE, 1981) that the resident population of demersal fish has been increased by species of fish common in the Indopacific Ocean, which have immigrated to the Eastern Mediterranean, presumably through the Suez canal, and have survived until they are now of economic importance.

Two such fish, Upeneus moluccensis (BLEEKER, 1955) and Saurida undosquamis (RICHARDSON 1848), were selected and their mercury contents in the muscle tissues determined as a function of such parameters as size, age, sex, season and location. In addition to these parameters, the mercury contents of particular tissues in some selected samples were investigated.

The results have been compared in particular with Mullus barbatus and also with those obtained from fish such as Mullus surmuletus, and Mugil auratus which are native to the Levantine.

Materials and methods

Fish samples were collected from three stations, Tirtar, Goksu delta and Seyhan delta located along the southeastern coast of Turkey (Figure 1). Sampling cruises were carried out every month from November, 1980 to September, 1981. The age was determined by examination of otoliths and the results were supported by length distribution data 1,752 individual fish given elsewhere (DAE, 1981). Preservation of the samples, sample preparation and analysis were carried out by following the procedure recommended in FAO Technical Paper No. 158 (FAO, 1976) The mercury concentrations were determined by a cold-vapour atomic absorption technique using a Varian Techtron Model AA-6 AAS (TUNCEL et al., 1980).

Intercalibration fish homogenate samples (obtained from the IAEA, Monaco Laboratory) were used as a control for the analytical methods.

Results and discussion

The total mercury concentrations in the U. moluccensis and S. undosquamis species of the same age group, caught in different months, are given in Table 1. As can be seen from the Table, the average mercury contents of female and male fish samples within the experimental error limits are almost identical. Accordingly the results in the following discussion will be given without consideration of the sex of the species.

Although it is very well established that S.undosquamis in Goksu delta and Tirtar have significant differences in feeding habitat (BINGEL, 1982), from the results given in Table 2 it is clear that there is no remarkable difference in the mercury levels in species caught at the same time from these two locations.

Table 1. Dependence of mercury concentration on sex in U. moluccensis and S. undosquamis (Hg concentrations in ng/g F.W.)

Sampling months	*Upeneus moluccensis* Female		Male		*Saurida undosquamis* Female		Male	
NOV.1980/DEC.1980	(5)	19±3	(3)	22	(2)	19	(1)	49
JAN.1981/FEB.1981	(9)	32±5	(11)	39	(9)	37±8	(5)	46±8
MAR.1981/APR.1981	(3)	46	(5)	51±5	(14)	47±16	(10)	52±12
MAY.1981/JUN.1981	(6)	124±47	(1)	112	(9)	58±13	(2)	42
JUL.1981/AUG.1981	(25)	87±25	(7)	111±38	(5)	32±3	(2)	28
SEPT.1981	(3)	36	-		(6)	34±19	(2)	30

Number of samples are given in parentheses

Table 2. Dependence of mercury concentrations on locality in U. moluccensis and S. undosquamis

Species	S. Date	S. Location	No.of Individuals Analysed	Age Group	Fork Length Range (cm)	Range of Weights (g)	Hg (ng/g) (F.W.)
U.moluccensis	NOV.1980	Tirtar	2	0	7.5-10.0	5.45-14.60	30
		Göksu	4	0	9.5-10.0	14.20-12.20	22±5
		Seyhan	9	0	9.0-11.0	12.40-22.20	21±7
	DEC.1980	Tirtar	4	0	8.0-9.0	9.40-12.20	19±4
		Göksu	4	0	9.5-10.5	15.00-20.90	25±4
		Seyhan	2	0	9.0	11.40	15
	MAR.1981	Tirtar	3	I	10.0-11.5	14.83-23.26	48±12
		Göksu	8	I	9.5-11.5	12.79-22.60	50±7
		Seyhan	6	I	9.0-11.0	9.83-21.28	49±9
S.undosquamis	JAN.1981	Tirtar	4	I	17.0-20.0	43.20-58.60	53±11
		Göksu	4	I	16.0-19.5	38.60-59.40	48±15
		Seyhan	4	I	16.5-19.0	34.10-52.80	68±18
		Tirtar	12	II	17.0-23.0	36.90-91.80	48±14
		Göksu	8	II	17.0-20.0	39.10-61.60	40±11
		Seyhan	3	II	14.5-17.5	24.40-43.30	38±6
		Tirtar	5	II	17.0-20.5	39.18-71.37	42±9
		Göksu	10	II	13.5-23.0	20.24-99.04	61±21
		Seyhan	4	II	16.0-19.5	32.24-57.51	59±31

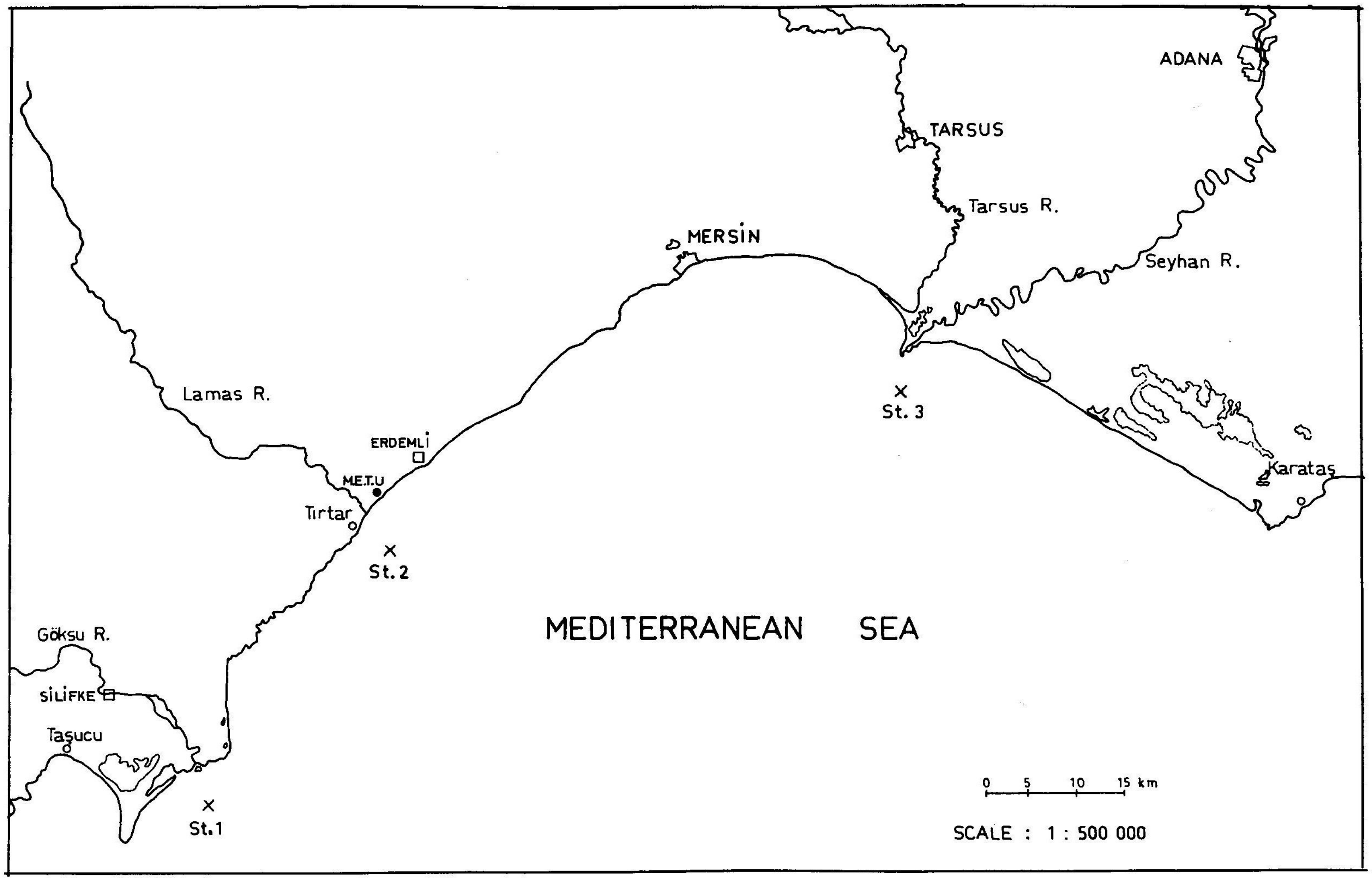


Figure 1. Sampling locations in the southeast Mediterranean coast of Turkey

Table 3. Correlation equations for the relationship between fork length, age group (years) and mercury concentrations

Species	No. of Individuals Analysed	Group	r	correlation equation(c)
<u>U. moluccensis</u>	257	5a)	0.997	$C_{Hg}=10^{0.306A-1.600}$
		11b)	0.952	$C_{Hg}=0.114\ L^{2.833}$
<u>S. Undosquamis</u>	157	7a)	0.990	$C_{Hg}=10^{0.162A-1.502}$
		20b)	0.985	$C_{Hg}=10^{0.086L-0.00103}$

a) Number of age groups
b) Number of fork length group with 1 cm length intervals
c) A is the age group (in years) and L is the mean fork length (in cm).

Table 4.

Species	Age	No. of Individual Analysed	F. length (cm)			Weight (g)			Hg, (ng/g, F.W.)		
			Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
<u>U. moleccensis</u>	0	45	7.5	11.0	9.4	5.5	23.2	14.7	11	154	36±34
	I	145	8.0	15.0	11.6	7.2	57.2	22.5	21	458	85±56
	II	58	9.5	17.5	13.2	14.3	97.8	39.0	53	510	183±122
	III	9	12.5	17.0	15.1	32.4	86.9	58.9	141	590	329±144
	IV	3	15.0	17.0	15.7	52.3	86.4	58.8	361	779	618
<u>S.undosquamis</u>	0	24	11.0	19.0	15.8	45.7	59.4	41.3	10	133	35±15
	I	59	13.0	21.5	17.2	18.8	86.7	45.3	21	154	50±26
	II	57	15.5	23.0	18.5	26.6	99.0	55.5	25	165	58±28
	III	13	17.0	26.0	21.4	39.1	151.1	99.5	36	129	81±30
	IV	1	-	-	25.0	-	-	141.8	-	-	147
	V	1	-	-	27.0	-	-	206.2	-	-	217
	VI	4	30.0	32.0	31.1	262.1	309.6	284.4	-	-	315

Table 5. Total mercury concentrations (ng/g, F.W.) in various tissues of *U. molluccensis* and *S. undosquamis*

Species	S.Date	Age	Muscle	Skin	Gills	Digestive Organs	Liver	Heart	Gonad	Fin Scales	Head	Back bone
U. moluccensis	Jan.1981	II	121±7	59	39	55	67	65	68	10	51	32
	Feb.1981	I	473±55	393	182	245	484	254	282	47	114	119
	Mar.1981	II	269±16	165	89	124	350	105	65	29	96	54
	Apr.1981	II	454	151	65	156	-	137	104	34	108	-
	May.1981	III	590±30	429	320	458	675	-	420	68	227	307
	Jun.1981	II	290±24	95	78	62	174	290	70	30	101	77
S. undosquamis	Feb.1981	II	46±1	24	40	48	50	32	28	-	37	33
	Mar.1981	I	56±3	27	40	50	54	34	30	-	30	30
	Apr.1981	II	53±3	29	40	56	38	31	13	-	31	28
	May.1981	II	165±13	81	113	210	217	132	63	-	95	91
	Jun.1981	II	91±2	28	48	53	68	37	15	-	40	38

Table 6. Seasonal variation of mercury concentration

Sampling Date	n[d)]	*U.moluccensis* a		n[d)]	*M. barbatus* b		n[d)]	*S.undosquamis* c	
		Hg,ppb,F.W.	Hg.pp,D.W.		Hg,ppb,F.S.	Hg.ppb.D.W.		Hg.ppb,F.W.	Hg,ppb,D.W.
Oct.1980	-	-	-	-	-	-	5	43±15	204±67
Nov.1980	13	23±8	100±33	2	47	179	3	34±5	177±26
Dec.1981	3	26±4	109±12	-	-	-	2	37	188
Jan.1981	12	34±8	170±43	4	26±7	123±39	10	51±12	226±55
Feb.1981	10	35±4	164±25	-	-	-	18	44±13	242±70
Mar.1981	13	51±7	244±30	15	59±28	275±128	9	48±16	226±77
Apr.1981	5	54±8	249±30	-	-	-	4	57±21	283±111
May.1981	7	90±70	421±134	7	48±17	211±74	3	55±22	244±93
Jun.1981	7	164±24	717±100	4	62±18	301±78	3	74±14	327±69
Jul.1981	10	91±44	443±215	12	63±9	204±57	6	41±12	186±55
Aug.1983	19	95±22	414±86	3	60±10	224±40	11	20±4	139±23
Sep.1983	3	36±15	122±50	8	57±27	249±128	1	28	128

a) Mean fork length :10.1-11.0 cm., age I

b) Mean fork length :13.0-14.0 cm., age I-II

c) Mean fork length :17.0-18.0 cm., age I-II

d) n is the number of species analysed

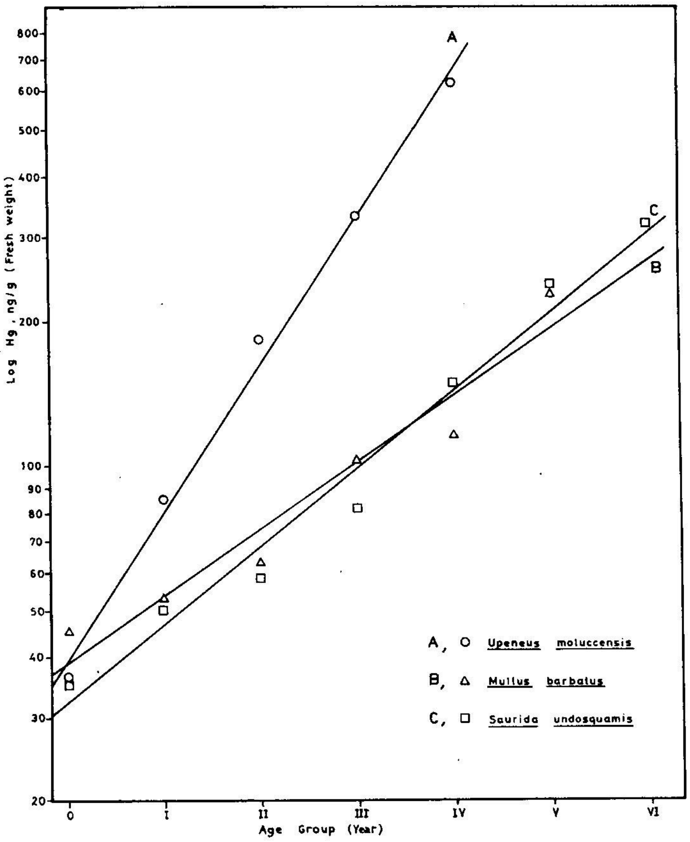


Figure 2. Linear regression lines for mercury concentration versus age relationship in Upeneus moluccensis, and Saurida undosquamis

Table 7. Total mercury concentrations (ng/g, F.W.) in some species of fish of the Levantine Basin

Species	Fork length (cm) n	Range	Mean	Hg, ng/g, F.W. Range	Mean	Sampling area	References
U. moluccensis	257	7.5-17.5	11.5	11-779	78	S.E. Coast of Turkey	This work
	39	8.9-20.6[a]	-	95-1019	566	Israel Coast	HORNUNG et al., 1980
	18	14.5-17.5	16.0	310-560	-	Israel Coast	YANNAI and SACHS, 1978
M. barbatus	94	8.0-23.0	14.0	14-369	62	S.E. Coast of Turkey	This work
	50	10.2-23.0[a]	-	35-375	128	Israel Coast	HORNUNG et al., 1980
	103	11.0-17.0[a]	-	50-290	-	Israel Coast	YANNAI and SACHS, 1978
	8	7.2-13.7	-	60-402	252	Egypt Coast	EL SOKKARY, 1980
M. surmuletus	36	8.5-20.5	13.6	14-167	71	S.E. Coast of Turkey	TURGUL et al., 1980
	9	7.3-16.8	-	42-2200	1032	Egypt Coast	EL SOKKARY, 1980
M. auratus	30	13.7-39.5	25.0	9-54	24	S.E. Coast of Turkey	TURGUL et al., 1980
	4	-	29.0[a]	-	40	Egypt Coast	YANNAI and SACHS, 1978
S. undosquamis	157	11.0-32.0	18.0	10-422	51	S.E. Coast of Turkey	This work
	62	12.3-31.5[a]	-	45-649	166	Israel Coast	HORNUNG et al., 1980
	70	18.0-33.5[a]	-	80-510	-	Israel coast	YANNAI and SACHS, 1978

a) total length of the samples.
n is the mumber of individuals analysed.

The number of individuals analysed for each species were 257 U. moluccensis , 157 S. undosquamis and 94 M. barbatus. The samples of each species were grouped at 1.0 cm intervals with respect to fork length. An exponential correlation between the mercury concentration in fish muscle and fork length of U. moluccensis and S. undosquamis was calculated. The data for M. barbatus showed too much scattering. The confidence level of the exponential correlation was 0.95 with a significance level of 100 a (where a + 0.05). The correlation equations and correlation coefficients are given in Table 3. The correlation coefficients for U. moluccensis and S. undosquamis are 0.952 and 0.885 respectively. When total mercury concentrations are grouped with respect to the age groups of the species, an exponential correlation equation between age group (years) and mercury concentrations can be derived for all species studied. The mean mercury concentration obtained from the analysis of the species in different age groups are given in Table 4. A plot of the logarithm of the mean mercury values of each age group against time (years) gives a linear curve for each species (Figure 2). Using the curves in Figure 2 and the data given in Table 4, the correlation coefficients of mercury concentrations versus age of the fish were examined. The calculated values after linear regression analysis are 0.997 and 0.990 for U. moluccensis and S. undosquamis respectively. The two coefficients are close to unity showing that the exponential correlation equations given in Table 3 are valid.

A second significance of Figure 2 is to point out the accumulation rate of mercury. It can be seen that the accumulation of mercury by U. moluccensis is higher than that of S. undosquamis. This observation appeared questionable since U. moluccensisis one of the preys of S. undosquamis and it was therefore expected to measure a higher mercury concentration in S. undosquamis. However these species certainly have a different metabolism. The physiological changes occurring in the metabolism of the fish, in particular spawning of the organism, may well affect the accumulation, transformation and excretion processes of mercury in different ways.

The distribution of mercury concentration in different tissues of the species was also investigated. The results obtained are given in Table 5. As is obvious from the Table, most of the mercury in the fish is deposited in the muscle and liver. The relatively high mercury content in the liver indicates that the transportation of mercury which is taken up from both sea-water and from food, is through the organism via its bloodstream.

The seasonal variation of the average mercury concentrations obtained from the analysis of muscle of species belonging to the same age group are given in Table 6. The results are calculated both on a fresh weight and a dry weight basis. Figure 3 was obtained by plotting Hg concentrations given in Table 6 versus the month of catch. The fresh weight concentrations are not included in Figure 3 since dry weight values reflect the variations much better and eliminate the variations which might be due to different water content of the tissue. M. barbatus results are not shown in Figure 3 since there is no significant seasonal variation in the mercury concentrations (see Table 6. The seasonal variation of mercury concentrations in U. moluccensis which belong to age group 1 (year) is shown in Figure 3(a). The mercury concentrations start to increase in April-May and reach amaximum in June-July. This observation is consistent with that of TURGUL et al., (1980) for Mugil auratus and Portunus pelagicus. The increase of mercury concentrations coincide with the application of mercury compounds to the crops of the area and rainfall. After July and August there is a considerable decrease in the mercury concentrations. Although this decrease is during the spawning period, it can be seen from Table 5 that the gonads of both male and female do not contain relatively much higher mercury and therefore it would not be wise to base the decrease on excretion by spawning. It is probable that there is another parameter i.e. a change in feeding habitat as in S. undosquamis (BINGEL, 1982) which controls the excretion mechanism. The mercury concentration in S. undosquamis (age group I and II years) are lower than the concentrations in U. moluccensis but the seasonal variation trend is the same (Figure 3(b)). S. undosquamis spawns twice a year, once during May-June and again in Septeber-October (DAE, 1981). The seasonal variation and especially the decrease of mercury concentrations in U. moluccensis and S. undosquamis indicate that the excretion mechanism of fish should be fully investigated before drawing any conclusions.

In general, the mean mercury concentrations in fish reported from other parts of the Levantine, i.e., from the Israeli and Egyptian coasts, are higher than those from the Turkish coast (Table 7). These differences may well be due to the differences in either the size or age of the fish analysed and also to the analytical methods used. A clear example of this is the U. moluccensis; the mean fork length of the samples used in this work was 11.5 cm, whith mercury concentration at 78 ng/g, while from the Israeli coast (HORNUNG et al., 1980), the length was 16.0 cm and total mercury concentration was 566 ng/g. As was stated previously , the mercury concentrations increase exponentially with increasing length, possibly causing the differing results. The number of individual fish analysed might also affect the average values. In the case of M. barbatus, the number of individuals analysed in this work was 94, the range of mercury being between 14 and 369 ng/g, and the mean value, 62. The mercury ranges, in particular the upper limits reported from the Israeli coast (HORNUNG et al., 1980) and from the Egyptian coast (EL SOKKARY, 1980) are very close to our values. However, the number of species were lower and the mean mercury concentrations were higher. With the decreasing number of specimens, the probability of having a homogeneous either length or age group distribution decreases, so the results become more random.

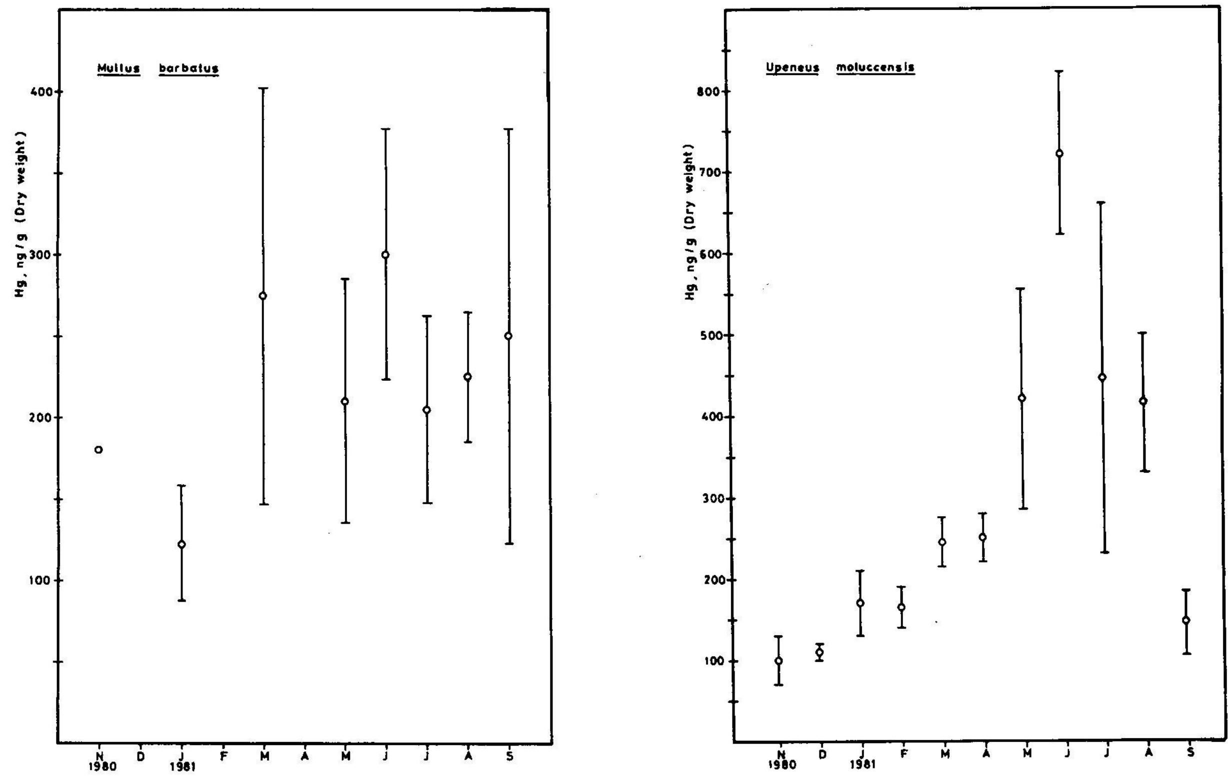
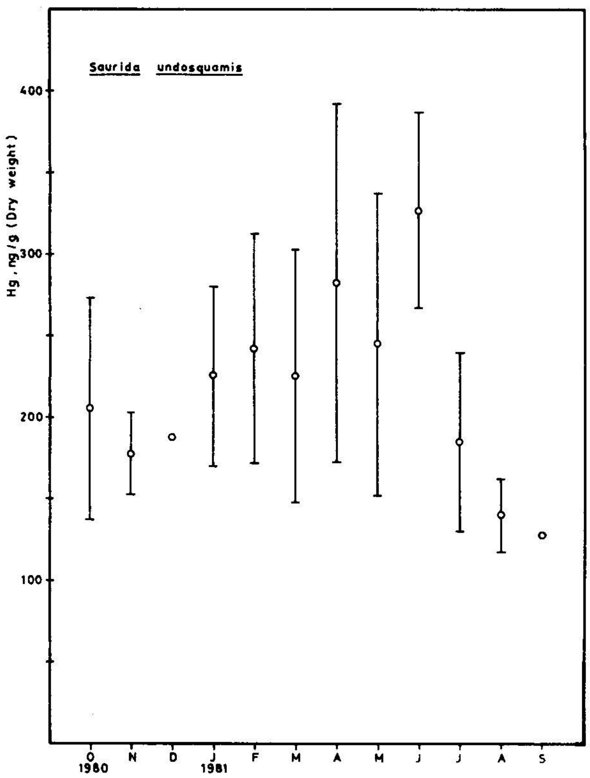


Figure 3. (a) Seasonal variation of mercury concentration in Mullus barbatus

(b) Seasonal variation of mercury concentration in Saurida undosquamis



(c) Seasonal variation of mercury concentration in Saurida undosquamis

Summary

Variation of mercury concentrations in U. moluccensis, S. undosquamis and M. barbatus with respect to fork length and age of the species was investigated disregarding the differences in sex and sampling locations since these factors have no effect on the accumulation of mercury by all the species studied. Statistical analysis of 257 U. moleccensis specimens analysed revealed a high dependence of mercury concentration (95% confidence level) on both fork length and age data, while that for 157 S. undosquamis specimens was much lower.

Total mercury concentration in U. moluccensis also points out a significant variation as a function of the seasons (Figure 3(a)). The maximum mercury concentration found in U. moluccensis, and to a lesser extent in S. undosquamis, coincides with the local application of mercury fungicides in the southeastern coast of Turkey.

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