

**INVENTORY OF EXISTING SPECIES
AND THEIR HABITATS
IN THE BOSPHORUS AREA
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Abstract:

The commercial fisheries in Turkey mainly depends on pelagic species. It is a well-known fact that most of the pelagic fishes of Turkish Seas migrate to the Black Sea for grazing and fattening. They usually spawn in warmer waters of the Sea of Marmara and Aegean Sea, as a consequence of which they migrate away from Black Sea during the Autumn of each year. In the course of these migrations, landing works as big quantities in and around Turkish straits. Seasonal occurrence of commercially important fish species are discussed in this article.

BRIEF DESCRIPTION OF THE HYDROGRAPHICAL FEATURES OF THE AREA

The Turkish Straits extend from the Aegean Sea to the Black Sea trough the Dardanelles (60 km). Sea of Marmara (210 km.) and Bosphorus (31km.). The total length of the Straits is approx. 300km. Because of great density differences between the Mediterranean and the Black Sea waters, there is a two layer current system along the Straits flowing in opposite directions.

The water masses of the Black Sea are entirely different from those of the Mediterranean proper. Because of the Black Sea precipitation and runoff exceeds evaporation, the surface layer of relatively low salinity and correspondingly low density are present. Vertical mixing tends to reduce the density of the deeper surface layer (approx. 200m.) which therefore has a lower density than that of the water in the Aegean Sea at the same depth. Owing to the distribution of density, the surface waters of the Black Sea flow out trough the Bosphorus and the Dardanelles into the Aegean basin and Mediterranean water flows in along the bottom.

The outflow from the Black Sea basin is a function of its water budget and carries runoff from the large rivers and surface waters running into the Black Sea.

In Table 1. The water budgets along with the major fresh water sources are given. The outflow is also a function of excess of precipitation over evaporation from the 423.000 km² Black Sea surface.

ACTIVE	km ³	%		PASSIVE	km ³	%
Runoff (Q)	336	53.16		Evaporation (E)	340	53.80
Precipitation (P)	120	18.99				
Outflow of water from the strait of Kerch (K)	53	8.39		Inflow of water to the Azov Sea (Ki)	32	5.06
Inflow of water trough the Bosphorus (B)	123	19.46		Outflow of water trough Bosphorus (Bo)	260	41.16
TOTAL:	632	100.00			632	100.00

$$Q + P + K + B = E + Ki + Bo = 632 \text{ km}^3$$

Table1. Water Budge of the Black Sea

Intensive mixing takes place along the Bosphorus as well as in the other parts of the Straits. The salinity of the inflowing Mediterranean water which is over 38,50 o/oo at the entrance of the Dardanelles decreases slowly with the distance traveled in the Sea of Marmara down to 29 o/oo, where the bottom current enters the Black Sea at the northern end of the Bosphorus. At the same time the salinity of the out flowing water is increased from 16 o/oo to 30 o/oo leaving the Dardanelles.

This increase is a function of the distance traveled by the water as shown in Table 2.

Rivers	Drainage area (km²)
Danube	386.000
Dniester	61.900
Bug	34.000
Dnieper	538.000
Don*	446.000
Kuban*	63.000
Rivers of Caucasus	24.000
Rioni	15.000
Coruh	16.000
Turkish rivers	231.500
Rivers of Bulgaria	22.200
Total:	2.290.200

(* to the Azov Sea.)

Table 2. Major rivers of the Black Sea Basin

The out - and inflowing water masses are separated by a well-defined layer of transition which oscillates up and down according to the contours of the bottom. This transition layer also represents the discontinuity layer for temperature and salinity and called thermo-halocline. In Table 3. seasonal changes (range) of temperature at different depths of the Bosphorus area are presented. As it will be seen from this table the range of min. and max. temperature decreases with the depth and is practically nil below 200m.

Depth	Range T°C
0	14.9
10	14.2
25	6.8
50	0.6
75	0.3
100	0.3
200	0.1

Table 3. Seasonal variations of sea water temperatures at different depths in the Bosphorus area.

The permanent transition layer is an obstruction for mixing and therefore an oxygen deficit in the waters of the Straits are observed. Although anoxic conditions are not observed except in the deep and stagnant waters of the Black Sea (Sub-area I.) and polluted waters of the Golden Horn (Sub-area III.) the dissolved oxygen concentration of the Bosphorus and the Sea of Marmara is very low (approx. 2.5 mg/l below the thermocline). Surface concentrations of dissolved oxygen vary from 7.98 to 5.39mg/l with an average of 7.6 mg/l for the Bosphorus area. On the other hand bottom concentrations are as low as 1.20mg/l with an average of 2.1mg/l for the waters of the area.

In Table 4. average dissolved oxygen concentrations for the different depths in the Bosphorus area are presented.

depth in m	DO conc.mg/l	DO conc.ml/l
0	7.6	10.85
10	7.3	10.42
25	6.7	9.57
50	4.1	5.86
75	3.2	4.57
100	2.6	3.71
200	2.4	3.42

Table 4. Vertical distribution of dissolved oxygen as average concentrations in the Bosphorus area.

ECOLOGICAL CHARACTERISTICS OF THE AREA

After 1950 a number of hydrographical investigations have been carried out by different Institutions such as the Hydrobiological Research Institute of the University of Istanbul, Istanbul Technical University, Aegean University, Middle East Technical University and Turkish Navy's Hydrographic Office. Also investigations carried out by the Projects like DAMOC, CAMP-TEKSER, SWECO and others have greatly contributed to the knowledge of the hydrography of the waters of Turkish Straits.

The Bosphorus where the active exchange and mixing of the Mediterranean and the Black Sea takes place occupies 10 percent of the Turkish Straits, which is composed of the Bosphorus, Sea of Marmara and the Dardanelles.

The Bosphorus as a meandering strait has an average width of 1.6km. and an average depth of 35.8m., there is a two-layer current system in which Black Sea water of about 17.5 o/oo salinity flows southwards at the surface and Mediterranean water about 38 o/oo salinity flows north along the bottom of the strait.

The fundamental reason for these flows are the sea level differences between the two ends of the strait system, i.e. the Black Sea and the Mediterranean. Southerly flow of surface water from the Black Sea is caused by the difference in surface elevation between the north and the south ends of the Bosphorus.

According to TOLMAZIN (1985) a reduction of the discharge has taken place due to the post war Soviet Water Management Bosphorus, starting early 1950's. this reduction has considerably affected the water budget and led to an increase of salinity and to the "Mediterranization" of the Black Sea.

Unfortunately the available data is not enough to make an evaluation of the trends in salinity changes at present.

During the extensive surveys of the IRTC, sea level differences have been recorded reaching maximum values of 70cm. Based on long term observations, BOGDANOVA (1965) has reported a mean sea level difference of 42cm., with considerable variations throughout the year, with a maximum height of 52cm. Variations in sea level are due to tides, changes in river runoff and winds. Because of these two directional flows of water with different hydrographical characters, the water column in the Bosphorus area can be divided into three layers:

1. A surface layer with a salinity approx. 18 o/oo and temperatures varying according to the seasons, the extent and direction of the surface flow.

2. An interracial layer with a thickness up to 10m. at the southern and 2m. at the northern ends of the Bosphorus.

3. A bottom layer with a salinity of approx. 37 o/oo. and with an always stable temperature of 14.2°C.

Nekton of the Bosphorus area is predominantly fishes which comprise both surface layer swimming (Pelagic) species and species which are living on the bottom (Benthic) and the species taking place between the free water and the bottom (Semi-pelagic). Most of the fishes belonging to these habitats are migratory fishes originated either from the Mediterranean or from the Black Sea.

Biotic and abiotic conditions of the strait affect the distribution and diurnal and/or seasonal migration of the nekton and its food. Most important factor for their behavior is the temperature changes at both ends of the straits. Under the conditions of the Bosphorus, species living in the upper water department (surface layer) are more subject to these changes.

On the other hand the benthic or the semi-pelagic species can find suitable temperatures, almost unchanged throughout the seasons in the water department under the thermocline.

This characteristic temperature distribution may be changed and a homothermous cold water mass may be formed lasting only 2 or 3 days during February - March, which may lead to mass mortality of fishes in the Bosphorus. This type of formation has been observed also during Bosphorus surveys.

1. 1. FISHES OF BOSPHORUS AREA:

A list of fish species from the sub-regions is given in Table I, with indications of their habitat (HAB), (P) representing pelagic, (D) demersal and (SP) semipelagic species of fishes. In these tables relative abundance of species are given as follows:

(- Not present. + Present but rare., ++ Found frequently., +++ Abundant.)

I. Black Sea, II. Bosphorus, III. Golden Horn, IV. Sea of Marmara

List of fishes in the project area.

SPECIES	Sub-regions					HAB.
	I.	II.	III.	IV.		
Teleostei						
<i>Alosa fallax nilotica</i> (Geof.)	++	+	-	+		P
<i>Ammodytes cicerellus</i> (Rafin.)	+	-	-	+		D
<i>Anguilla anguilla</i> (L.)	+	-	-	+		D
<i>Aphyia minuta</i> (Risso.)	++	+	-	++		D
<i>Argentina sphyraena</i> (L.)	-	-	-	+		P
<i>Arnoglossus grohmanni</i> (Bonap.)	+	+	-	+		D
<i>Arnoglossus kessleri</i> (Schmi.)	+	+	-	+		D
<i>Arnoglossus laterna</i> (Willugh.)	+	+	-	+		D
<i>Atherina hepsetus</i> (L.)	+	+	-	+		P
<i>Atherina mochon</i> (Cuv.-Val.)	+++	+++	-	++		P
<i>Belone belone</i> (L.)	+++	+++	-	++		P
<i>Blennius galerita</i> (L.)	+	+	-	+		D
<i>Blennius gattorugine</i> (Brun.)	+	+	-	+		D

<i>Blennius ocellaris</i> (L.)	+	+	-	+	D
<i>Blennius pavo</i> (Risso.)	+	+	-	+	D
<i>Blennius sanguinolentus</i> (Pall.)	+	+	-	+	D
<i>Blennius sphinx</i> (Cuv.-Val.)	+	+	-	+	D
<i>Blennius tentacularis</i> (Brun.)	+	+	-	+	D
<i>Boops boops</i> (L.)	+	-	-	+	SP
<i>Boops salpa</i> (L.)	+	-	-	+	SP
<i>Callionymus belenus</i> (Risso.)	++	-	-	-	D
<i>Callionymus festivus</i> (Pall.)	++	-	-	-	D
<i>Callionymus lyra</i> (L.)	-	-	-	+	D
<i>Capros aper</i> (L.)	-	-	-	+	SP
<i>Cepola rubescens</i> (Gruvel.)	-	-	-	++	SP
<i>Charax puntazzo</i> (L.)	+	-	-	++	SP
<i>Chromis chromis</i> (L.)	+	+	-	+	D
<i>Citharus linguatula</i> (L.)	-	-	-	+	SP
<i>Conger conger</i> (L.)	+	+	-	+	D
<i>Corvina nigra</i> (Bloch.)	+	+	-	++	SP
<i>Crenilabrus griseus</i> (L.)	++	++	+	++	SP
<i>Crenilabrus mediterraneus</i> (L.)	++	++	+	++	SP
<i>Crenilabrus ocellatus</i> (Forsk.)	++	++	+	++	SP
<i>Crenilabrus tinca</i> (Brun.)	++	++	+	++	SP
<i>Crenilabrus tigrinus</i> (Risso.)	++	++	+	++	SP
<i>Ctenolabrus rupestris</i> (L.)	+	+	-	+	SP
<i>Dentex dentex</i> (L.)	+	+	-	++	D
<i>Dicentrarchus labrax</i> (L.)	++	++	-	++	D
<i>Diplodus annularis</i> (L.)	+	+	-	++	SP
<i>Diplodus vulgaris</i> (L.)	+	+	-	++	SP
<i>Engraulis encrasicolus</i> (L.)	+++	+	-	+	P
<i>Flessus vulgaris</i> (Moreau.)	+	+	-	+	D
<i>Gadus euxinus</i> (Nord.)	+++	+	+	+	D
<i>Gadus merlangus</i> (L.)	+	+	-	+++	D
<i>Gaidropsaurus mediterraneus</i> (L.)	+	++	-	++	D
<i>Gasterosteus aculeatus</i> (L.)	+	+	-	+	SP
<i>Gobius cobitus</i> (Pall.)	+	+	-	+	D
<i>Gobius cruentatus</i> (Brunn.)	+	+	-	+	D
<i>Gobius kessleri</i> (Gunth.)	+	+	-	+	D
<i>Gobius melanostomus</i> (Pall.)	+	+	+	+	D
<i>Gobius niger</i> (L.)	+	++	+	+	D
<i>Gobius paganellus</i> (L.)	+	+	-	+	D
<i>Gobius platyrostris</i> (Pall.)	+	+	-	+	D
<i>Gobius rattan</i> (Nord.)	+	+	-	+	D
<i>Gobius syrman</i> (Nord.)	+	+	-	+	D
<i>Hippocampus brevisrostris</i> (Cuv.)	+	++	-	+	D
<i>Julis vulgaris</i> (Cuv.-Val.)	+	+	-	+	SP
<i>Labrus bergylta</i> (Asconius.)	+	+	+	+	SP
<i>Labrus mixtus</i> (L.)	+	+	+	+	SP
<i>Labrus merula</i> (L.)	+	+	+	+	SP
<i>Labrus turdus</i> (L.)	+	+	+	+	SP
<i>Labrus viridis</i> (L.)	+	+	+	+	SP
<i>Lepadogaster bimaculatus</i> (Penn.)	+	+	-	+	D
<i>Lepadogaster candollii</i> (Risso.)	+	+	+	+	D
<i>Lepadogaster gouannii</i> (Lacep.)	+	+	+	+	D
<i>Lepidotriglia aspera</i> (Cuv.-Val.)	++	++	-	+++	D
<i>Lichia amia</i> (L.)	-	-	-	++	P
<i>Lophius piscatorius</i> (L.)	+	+	-	+++	D
<i>Maena chrysalis</i> (Cuv.-Val.)	+++	+++	+	+++	SP
<i>Maena vulgaris</i> (Cuv.-Val.)	+++	+++	+	+++	SP
<i>Molva elongata</i> (Otto.)	+	+	-	++	SP
<i>Mugil auratus</i> (Risso.)	+++	++	+	+++	D
<i>Mugil capito</i> (Risso.)	+++	++	++	+++	D

<i>Mugil cephalus</i> (L.)	+++	++	++	+++	D
<i>Mugil chelo</i> (Cuv.)	+++	++	+	+++	D
<i>Mugil saliens</i> (Risso.)	+	+	-	+++	D
<i>Mugil so-iuy</i> (Basilewsky.)	+	+	+	+	SP
<i>Mullus barbatus</i> (L.)	+++	+++	+	+++	D
<i>Mullus surmuletus</i> (L.)	+++	+++	-	+++	D
<i>Naucrates ductor</i> (L.)	+	+	-	+	P
<i>Nerophis teres</i> (Rarh.)	+	+	-	+	SP
<i>Ophidium barbatus</i> (L.)	+	+	-	+	D
<i>Pagellus erythrinus</i> (L.)	+	+	-	+++	SP
<i>Paracentropristis hepatus</i> (L.)	-	-	-	+++	SP
<i>Pegusa natus</i> (Pall.)	+	-	-	+	D
<i>Sarda sarda</i> (Bloch.)	+++	+++	-	+++	P
<i>Sardina pichardus</i> (Walb.)	+	+	-	+++	P
<i>Sciaena cirrosa</i> (L.)	+	+	-	++	D
<i>Scophtalmus maeoticus</i> (Pall.)	+++	+	-	++	D
<i>Scophtalmus maximus</i> (L.)	-	-	-	+	D
<i>Scophtalmus rhombus</i> (L.)	+	+	-	++	D
<i>Scomber japonicus</i> (Houtt.)	-	+	-	+++	P
<i>Scomber scomber</i> (L.)	++	+	-	++	P
<i>Scorpaena porcus</i> (L.)	++	++	-	+++	D
<i>Scorpaena scrofa</i> (L.)	-	-	-	+++	D
<i>Scorpaena ustulata</i> (Low.)	+	-	-	+	D
<i>Sebastes dactylopterus</i> (Gthr.)	-	-	-	+	D
<i>Serranus cabrilla</i> (L.)	++	++	-	++	SP
<i>Serranus scriba</i> (Cuv.-Val.)	++	++	-	++	SP
<i>Smaris alcedo</i> (Risso.)	+++	+++	+	+++	SP
<i>Smaris vulgaris</i> (Cuv.-Val.)	+++	+++	+	+++	SP
<i>Solea kleinii</i> (Risso.)	-	+	-	+	D
<i>Solea lutea</i> (Risso.)	-	+	-	+	D
<i>Solea melanochira</i> (Moreau.)	-	+	-	+	D
<i>Solea monochir</i> (Bonap.)	-	+	-	+	D
<i>Solea ocellata</i> (L.)	-	+	-	+	D
<i>Solea variegata</i> (Gunth.)	+	+	-	+	D
<i>Solea vulgaris</i> (Chab.-Hand.)	-	+	-	+	D
<i>Spyraena spyraena</i> (L.)	+	-	-	+	P
<i>Spratella spratus</i> (Risso.)	+++	-	-	+	P
<i>Symphodus scina</i> (Forsk.)	+	+	-	+	P
<i>Syngnatus acus</i> (L.)	+	+	+	+	SP
<i>Syngnatus schmidtii</i> (Popav.)	+	+	+	+	SP
<i>Syngnathus taeniotus</i> (Canes.)	+	+	-	+	SP
<i>Syngnathus typhle</i> (Rath.)	+	+	-	+	SP
<i>Temnodon saltator</i> (Cuv.-Val.)	+++	+++	+	+++	P
<i>Thunnus thynnus</i> (L.)	+	-	-	?	P
<i>Trachinus draco</i> (L.)	+++	+++	-	+++	SP
<i>Trachinus radiatus</i> (Cuv.)	+	+	-	++	SP
<i>Trachurus mediterraneus</i> (Stein.)	+++	+++	++	+++	P
<i>Trachurus trachurus</i> (L.)	+++	+++	+++	+++	P
<i>Trachipterus cristatus</i> (Bonel.)	-	+	-	++	P
<i>Trigla gurnardus</i> (L.)	+++	+++	-	+++	D
<i>Trigla lineata</i> (L.)	+	++	-	+++	D
<i>Trigla lucerna</i> (L.)	++	++	-	+++	D
<i>Trigla lyra</i> (L.)	-	+++	-	+++	D
<i>Trigla pini</i> (Bloch.)	++	+	-	+++	D
<i>Uranoscopus scaber</i> (L.)	++	++	-	++	D
<i>Xiphias gladius</i> (L.)	-	-	-	?	D
<i>Zeus faber</i> (L.)	+	-	-	+	D
<i>Zostericola ophiocephala</i> (Pall.)	+	-	-	+	D

1.2. MIGRATION PATTERNS OF THE COMMERCIALY IMPORTANT FISH SPECIES IN THE TURKISH COASTS

Because of the complex hydrographical and ecological conditions in the Sea of Marmara, the fish fauna is practically divided into three groups. This grouping is mainly based on the migration habits of the fish species in question.

- a) Black Sea forms (mainly pelagic)
- b) Mediterranean forms (mainly pelagic)
- c) Local fishes (mainly demersal)

The so called "**Black Sea forms**" are undertaking periodic, seasonal migrations between Black Sea and the Sea of Marmara either for spawning and/or feeding habits. This first group is represented by the following species:

<i>Engraulis encrasicolus</i>	Anchovy	Hamsi
<i>Sarda sarda</i>	Bonito	Torik/Palamut
<i>Scomber scomber</i>	Mackerel	Uskumru
<i>Temnodon saltator</i>	Bluefish	Lüfer
<i>Trachurus mediterraneus</i>	Horse mackerel	İstavrit

The so called "**Mediterranean forms**" are undertaking periodic, seasonal migrations between the Aegean and the Sea of Marmara for spawning and/or feeding. This group is composed by the following species:

<i>Boops boops</i>	Bogue	Kupes
<i>Boops salpa</i>	Salema	Sarpa (Çitari)
<i>Lichia amia</i>	Leerfish	Akya
<i>Sardina pilchardus</i>	Sardine	Sardalya
<i>Scomber japonicus</i>	Spanish mackerel	Kolyoz
<i>Thunnus thynnus</i>	Bluefin tuna	Orkinoz
<i>Xiphias gladius</i>	Swordfish	Kılıç

Contrary to these two groups "**Local forms**" are only making seasonal vertical migrations. Some representatives of this group are given below:

<i>Mullus barbatus</i>	Redmullet	Tekir
<i>Mullus surmuletus</i>	Surmullet	Barbunya
<i>Scophthalmus maeoticus</i>	Turbot	Kalkan
<i>Trigla gurnardus</i>	Gurnard	Kırlangıç

1.2.1. MIGRATION PATTERNS OF SOME IMPORTANT "BLACK SEA FORMS"

SARDA SARDA:

Different names are given by the local fishermen to the size groups of the *Sarda sarda*. In general **Torik** refers to the large size and **Palamut** to the young fish. Migration routes for *Sarda sarda* is given in figure 1.2.1.



Figure: 1.2.1. Migration Routes of Bonito

Sarda sarda migrates between the Black Sea and the Sea of Marmara, sometimes extending to the Northern Aegean down to the Gulf of Edremit. Bonitos migrate usually above the thermocline, forming dense schools of almost equal size groups. The migration takes place over the continental shelf and towards the Sea of Marmara in September-October. *Sarda sarda* usually spawns in the Black Sea and the young fish migrate in the autumn towards the feeding grounds in the Sea of Marmara, where they are caught in great quantities.

SCOMBER SCOMBER:

Migration routes of the Mackerel are shown in fig.1.2.2. Mackerels usually migrate between the Black Sea and the Sea of Marmara. But after construction of large reservoirs on the Russian rivers, the migration patterns of this fish have changed and from 1969 onwards they have stayed in the Sea of Marmara and later in the Northern Aegean. Only a small group makes the usual migration between the Black Sea and the Sea of Marmara. There are two distinct seasonal occurrence peaks for Mackerel. They usually form dense schools between the thermocline and the surface. Temperature range for the schooling is 6°C to 11°C.



Figure: 1.2.2. Migration routes and Spawning areas of the Mackerel

- 1. 2.and 3. Regular migration routes.
- 4. Extended route.
- 5. Main fishing area.
- 6. Early fishing area.
- 7. Late fishing area.

Spawning of Mackerels takes place in late March and the first half of April on the continental shelf of the Northern Aegean Sea, Gulf of Saros and/or near the Marmara Islands in the Sea of Marmara. In cold winters, when the thermocline sinks down to 50m. to 60m., they stay near the bottom in the warmer water mass of deeper parts of the Sea. Before the ecology of the Sea of Marmara was affected by the withdrawal of water from the Russian rivers after 1969, the spawning was taking place in the areas shown in figure: 1.2.3.

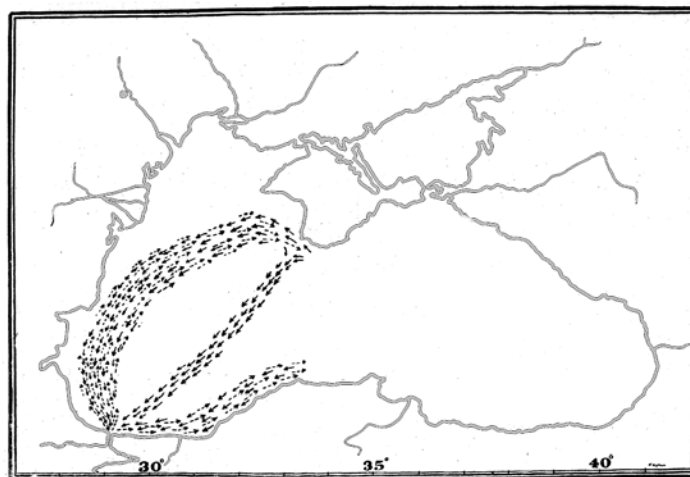


Figure: 1.2.3. Migration routes of the Mackerel before 1969 (Pektaş, 1956).

TEMNODON SALTATOR:

Migration routes of the *T. saltator* (Bluefish) are shown in Figure: 1.2.4. Dotted lines indicate the autumn migration and the solid lines the spring migration. As shown in the seasonal occurrence pattern of the Bluefish, migration peaks are clearly defined, the spring migration peak being in April and the autumn migration peak being in September. Blue fish usually migrates below the thermocline forming dense schools, especially during the spring migration. Bluefish is a warm water species and is severely affected by low temperatures. Temperatures below 6.5°C can cause mass mortalities on the stocks. In the winter of 1985 a very severe mass mortality of Bluefish occurred in the Bosphorus and Sea of Marmara. Spawning of Bluefish takes place in the upper layers (up to 25m.) on the continental shelf, starting from middle of April to the end of May. Both the eggs and the larvae are pelagic. Bluefish may also enter the lagoons for feeding.

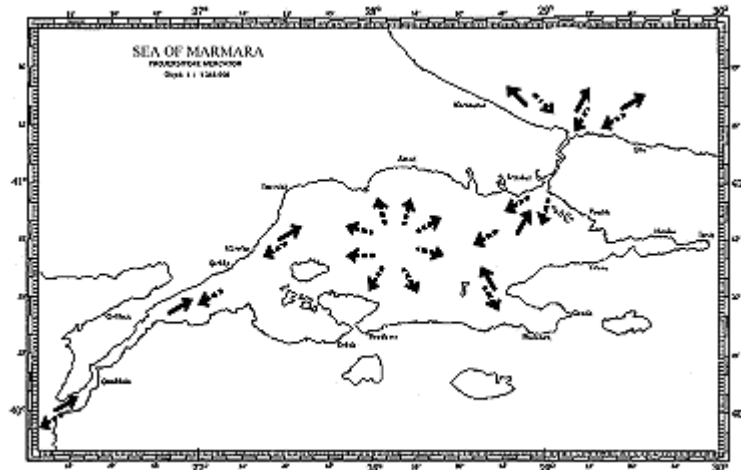


Figure: 1.2.4. Migration routes of the *Temnodon saltator*.

TRACHURUS MEDITERRANEUS:

There are two species of Horse mackerel in the project area as indicated in the list, but only *T. mediterraneus* forms dense schools in the area and therefore is more important from the fisheries point of view than the *T. trachurus* which is usually found in deeper parts.

Migration routes of the Horse mackerel and their spawning areas are shown in Fig: 1.2.5. as it will be seen from this figure migration in the Black Sea and in the Sea of Marmara occurs only over the shelf, close to the coast line.

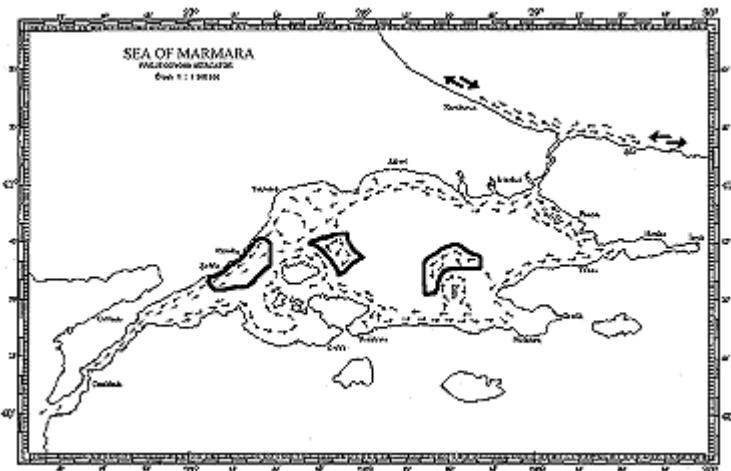


Figure: 1.2.5. Migration routes and Spawning areas of *T. mediterraneus*.

Horse mackerel is the most important fish species in the Bosphorus area, being the most abundant fish. *T. mediterraneus* migrates to the Black Sea in June for spawning and feeding. They stay all winter below the thermocline forming very dense schools usually close to the bottom. The schools are usually located between -20m. to -50m. Spawning of the *T. mediterraneus* takes place in the period of April-August. The eggs and larvae are both pelagic, usually concentrating near the surface. *T. mediterraneus* being a warm water fish species is severely affected by the cold temperatures i.e. below 6°C. This fish can stand changes in salinity and turbidity of the water as well as low oxygen and lower degrees of pH. therefore it can be found in considerable quantities in the polluted waters, such as the Golden Horn and Bay of İzmit.

1.2.2. MIGRATION PATTERNS OF SOME IMPORTANT “MEDITERRANEAN FORMS”

SARDINA PILCHARDUS:

Migration of sardines is directed by the hydrographical conditions of the surface layers of the Sea of Marmara. Abundance of these fish species in the Sea of Marmara depends primarily to the surface temperatures and salinities. Schooling of sardines in this area begins in the second half of May and lasts until the end of September. Planktonological investigations have shown that sardines spawn from August to the beginning of October. During this period eggs may be found from the surface down to 100 m depth. Larval stages may be found from September to March. Annual variations in the abundance of larval and post larval stages in the project area seem to be closely connected with variations in temperature and salinity. The most favourable temperatures for the post larval stages range between 9°C to 23 °C and salinities between 27 and 37 o/oo.

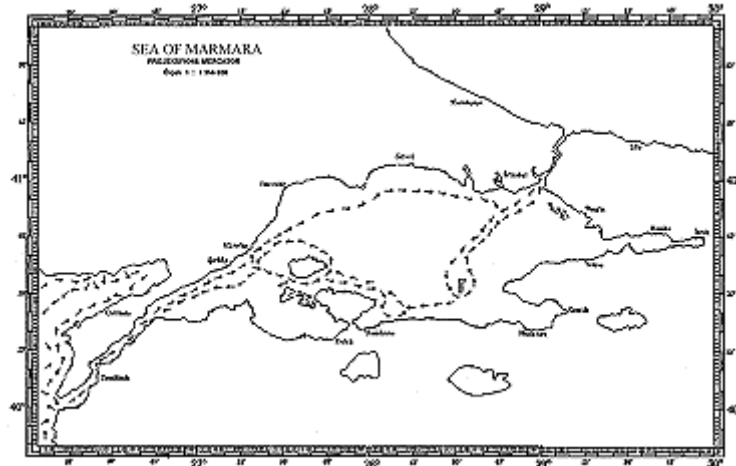


Figure: 1.2.6. Migration routes and of *Sardina pilchardus*.

Migration routes of sardines are shown in Fig: 1.2.6. Sardines migrate from the Aegean Sea into the Sea of Marmara in the beginning of May with the peak in June. Feeding of sardines depends mainly on plankton organisms. Scarcity of the plankton is another limiting factor for the migration of the sardines into the area.

THUNNUS THYNNUS:

Migration routes of the *Thunnus thynnus* (Bluefin tuna) are shown in Fig: 1.2.7. Bluefin tuna starts migrating from the Aegean Sea into the Sea of Marmara at the end of April, reaching the peak in July and ends in late August. The return migration occurs in late October and lasts till December. Spawning of the Bluefin tuna takes place in late July - August and sometimes early September. Both the eggs and larvae of the Bluefin tuna could be found in the Black Sea. Due to the pollutional effect of the “**Water Supply and Sewerage for the Istanbul Region**” application, the migration routes of Bluefin tuna to Black Sea have changed since 1985. Fig: 1.2.8 As a result of dramatic decrease of the migration of Bluefin tuna to Black Sea, the new migration route is limited because of the pollution of the Sea of Marmara so the migration gives a way only to the limited West part of the Sea of Marmara through the Dardanelles.

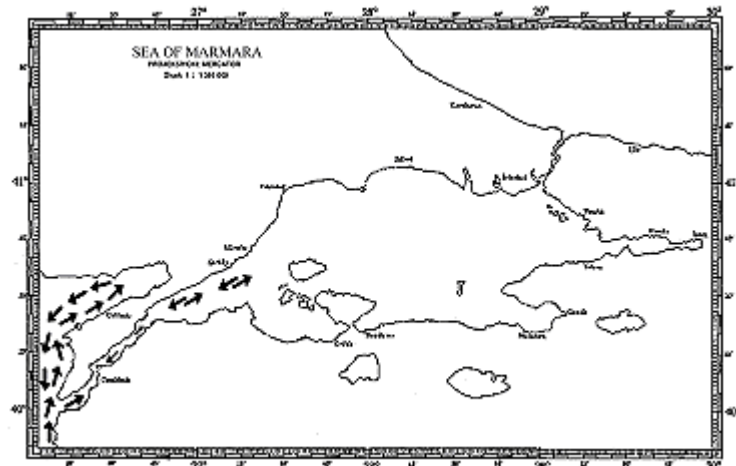


Figure: 1.2.7. Actual Migration routes of the *Thunnus thynnus*.

Spawning of the Bluefin tuna takes place in late July - August and sometimes early September. Both the eggs and larvae of the Bluefin tuna were found in the north part of the Aegean Sea. In some years tuna may stay all winter in the west part of Sea of Marmara depending on the availability of prey and temperatures over 10°C.

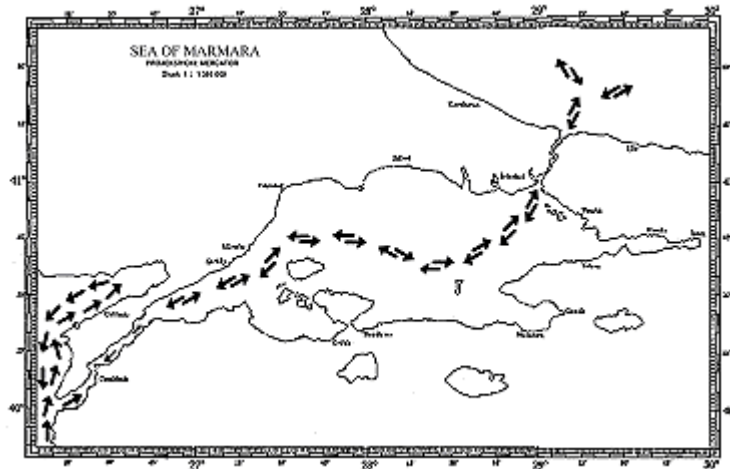
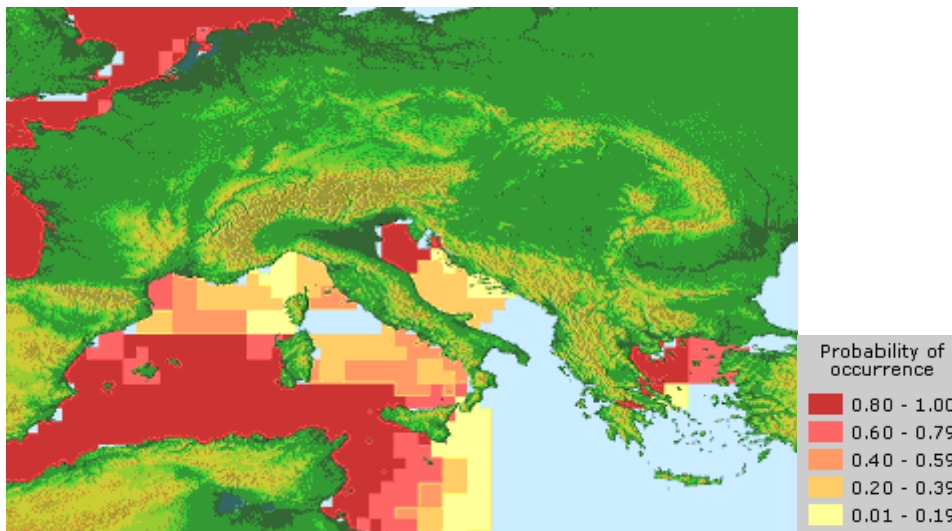


Figure: 1.2.7. Migration routes of the Bluefin tuna before 1985.

Bluefin tuna feeds on other migratory species such as sprat, bonito, mackerel, horse mackerel, anchovy and sardines. Therefore the migration of tuna is usually related to the migration of its prey. The fishing season (seasonal occurrences) of the tuna has its peak in the North part of Aegean Sea, in spring and in autumn corresponding to its migration.



The distribution map of Bluefin tuna in Mediterranean (Annex I. of the 1982 Convention on the Law of the Sea).

1.3. SPAWNING PERIODS AND TYPE OF EGGS AND LARVAE OF THE COMMERCIALY IMPORTANT FISH SPECIES IN THE BOSPHORUS AREA

In this section seasonal distribution of spawning of 55 species found in the Sea of Marmara are given. Some of these fishes spawn outside the limits of the Sea of Marmara but the eggs and/or larvae are found in the waters in question. In the lists below, types of eggs and larvae are also given (p= pelagic and d= demersal) As it will be seen from this list, pelagic types of eggs and larvae are dominating and with some exceptions most of the eggs and larvae are found on or above the thermocline. As in the example for the spawning areas for the mackerel, most of the eggs and larvae of fishes are distributed on the relatively shallow parts of the area up to the 100m. depth limit and eggs and larvae are found very seldom outside this limit.

SPAWNING PERIOD, ENVIRONMENT OF EGG AND LARVAL DEVELOPMENT OF MAJOR FISH SPECIES IN THE ECOSYSTEM OF THE SEA OF MARMARA (ARTÜZ 1982).

Species :	SPAWNING PERIODS												Type		
	M O N T H												E.	L.	CIT.
	1	2	3	4	5	6	7	8	9	10	11	12			
<i>Achantias vulgaris</i>	+	+	+	+	+	+	+	+	+	+	+		d	p	2
<i>Argentina sphyraena</i>	-	+	+	+	+	-	-	-	-	-	-	-	p	p	2
<i>Atherina hepsetus</i>	-	-	-	+	+	+	-	-	-	-	-	-	d	p	4
<i>Atherina mochon</i>	-	-	-	-	+	+	+	+	-	-	-	-	d	p	4
<i>Belone belone</i>	-	-	+	+	+	+	+	+	-	-	-	-	d	p	4
<i>Boops boops</i>	-	-	-	-	-	-	-	-	+	+	-	-	p	p	2
<i>Corvina nigra</i>	-	-	-	-	+	+	+	+	-	-	-	-	p	p	4
<i>Diplodus annularis</i>	-	-	-	+	+	+	+	+	-	-	-	-	?	?	4
<i>Diplodus sargus</i>	-	-	-	+	+	+	-	-	-	-	-	-	p	p	2
<i>Diplodus vulgaris</i>	-	-	-	-	-	-	-	-	+	+	-	-	p	p	2
<i>Engraulis encrasicolus</i>	-	-	-	+	+	+	+	+	+	+	-	-	p	p	1&4
<i>Euthynus alletteratus</i>	-	-	-	-	-	-	+	+	-	-	-	-	p	p	2
<i>Gadus euxinus</i>	+	+	+	+	+	-	-	-	-	-	-	-	p	p	1&4
<i>Gobius niger</i>	-	-	-	-	-	+	+	+	-	-	-	-	d	p	2
<i>Lithognathus mormyrus</i>	-	-	-	-	+	+	+	-	-	-	-	-	p	p	2
<i>Merluccius merluccius</i>	+	+	+	+	+	-	-	-	-	-	-	-	p	p	4
<i>Morone labrax</i>	-	-	-	-	-	-	+	+	-	-	-	-	p	p	4
<i>Mugil auratus</i>	-	-	-	-	-	-	-	+	+	-	-	-	p	p	4
<i>Mugil capito</i>	-	-	-	-	-	-	+	+	+	-	-	-	p	p	4
<i>Mugil cephalus</i>	-	-	-	+	+	+	+	+	-	-	-	-	d	p	4
<i>Mugil chelo</i>	-	-	-	-	-	-	-	+	+	-	-	-	p	p	4
<i>Mugil saliens</i>	-	-	-	-	-	-	-	+	+	-	-	-	p	p	4
<i>Mullus barbatus</i>	-	-	-	-	+	+	+	-	-	-	-	-	p	p	4
<i>Oblada melanura</i>	-	-	-	+	+	+	-	-	-	-	-	-	p	p	2
<i>Pagellus erythrinus</i>	-	-	-	+	+	+	-	-	-	-	-	-	p	p	2
<i>Pagrus ehrenbergii</i>	-	-	+	+	+	-	-	-	-	-	-	-	p	p	2
<i>Pleuronectes flesus</i>	+	+	+	-	-	-	-	-	-	-	-	-	p	p	4
<i>Sarda sarda</i>	-	-	-	-	+	+	+	+	-	-	-	-	p	p	4
<i>Sardina pilchardus</i>	-	-	-	-	-	-	+	+	+	+	-	-	p	p	4
<i>Scienza cirrhosa</i>	-	-	-	-	-	+	+	-	-	-	-	-	d	p	4
<i>Scomber colias</i>	-	-	-	-	-	+	+	+	-	-	-	-	p	p	1
<i>Scomber scomber</i>	-	-	+	+	+	+	-	-	-	-	-	-	p	p	1&4
<i>Scophthalmus maeoticus</i>	-	-	-	+	+	+	-	-	-	-	-	-	p	p	4
<i>Scophthalmus rhombus</i>	-	-	-	+	+	-	-	-	-	-	-	-	d	d	4
<i>Scorpaena porcus</i>	-	-	-	-	-	+	+	+	+	-	-	-	p	p	4
<i>Serranus cabrilla</i>	-	-	-	-	-	-	+	+	-	-	-	-	p	p	4
<i>Serranus scriba</i>	-	-	-	-	-	-	+	+	+	-	-	-	p	p	4
<i>Smaris alcedo</i>	-	-	-	-	+	+	+	+	-	-	-	-	d	p	4
<i>Solea vulgaris</i>	-	-	-	+	+	+	-	-	-	-	-	-	d	d	4
<i>Spratella spratus</i>	-	-	-	-	+	+	-	-	-	-	-	-	p	p	4
<i>Temnodon saltator</i>	-	-	-	+	+	-	-	-	-	-	-	-	p	p	4
<i>Thunnus thynnus</i>	-	-	-	-	-	-	+	+	-	-	-	-	p	p	4
<i>Trachurus mediterraneus</i>	-	-	-	+	+	+	+	+	-	-	-	-	p	p	1&3
<i>Trachurus trachurus</i>	-	-	-	-	+	+	+	-	-	-	-	-	p	p	4
<i>Trigla gurnardus</i>	-	-	-	-	-	+	+	-	-	-	-	-	p	p	4
<i>Trigla lucerna</i>	-	-	-	-	-	+	+	-	-	-	-	-	p	p	4
<i>Xiphias gladius</i>	-	-	-	-	-	+	+	-	-	-	-	-	p	p	4

E=Egg type
L=Larvae type
p=Pelagic d=Demersal

CITATIONS:
1=Demir N. 1957
2=Bini G. 1970
3=Numann W. 1954
4=Slastenenko 1956

REFERENCE

- AASEN, O. ARTÜZ, İ. and AKYÜZ, E. 1956** The Lampara Net in Turkish Waters. Reports F.R.C., M.F.O. Istanbul.
- AASEN, O. and ARTÜZ, İ. : 1956** Some observations on the Hydrography and Occurance of fish off the Black Sea Coast. Reports F.R.C.,M.F.O. Istanbul.
- AASEN, O. ARTÜZ, İ. And AKYÜZ, E. 1956** A contribution to the Fishery Investigations in the Sea of Marmara. Reports F.R.C. ,M.F.O. Istanbul.
- ACARA, A. 1957.** Relations between the migration of *Sadra sarda* BLOCH and prevailing temperature. Proc. Gen. Fish. Coun. Medit. Vol 4.
- AKŞIRAY, F. 1954.** Türkiyenin gezici ve geçici balıklarına kısa bir bakış. Balık ve Balıkçılık Mec. Cilt 2. EBK İSTANBUL.
- AKŞIRAY, F. 1954.** Türkiye Deniz balıkları tayin Anahtarı. İst.Üniv. Hidrobiol. Ar. Enst. yayınlarından sayı: 1.
- AKYÜZ, F. E. 1956.** Türkiyede Orkinos Balıkçılığı ve Avcılığı. Balık ve Balıkçılık Mec. Cilt 4, Sayı 2. EBK İSTANBUL.
- AKYÜZ, F. E. and ARTÜZ, I. 1957.** Some Observations on the Biology of Tuna "*Thunnus thynnus*" caught in Turkish Waters. Procc. Gen. Fish Counc. Medit. Vol. 4 ROME.
- ARIM,N. 1957.** Marmara ve Karadenizde bazı kemikli balıkların (Teleostların) yumurta ve larvalarının morfolojileri ile ekolojileri. Hidrobiyoloji,seri A,çilt 4,sayı 1-2.
- ARTÜZ, İ. 1956.** A Survey on Pelagic Fishing In Turkey. Balık ve Balıkçılık Mec. Cilt 4. Sayı 1. EBK İSTANBUL.
- ARTÜZ, İ. 1957** Bazı pelajik Balıklarımızda görülen av periyodları. Reports F.R.C.,M.F.O. Istanbul.
- ARTÜZ, İ. 1957** Türkiye Pelajik balıkçılığımıza bakış. Reports F.R.C., M.F.O. Istanbul.
- ARTÜZ, İ. 1958.** Kılıç balıkları hakkında. Balık ve Balıkçılık Mec. Cilt VI.sayı 11. Istanbul.
- ARTÜZ, İ. 1958.** Torik - Palamut (*Sarda sarda*) ların mevsim ve senelere bağlı av periodları. Balıkçılık Araşt. Merk. Raporları Seri B. Sayı 3. İSTANBUL.
- ARTÜZ, İ. 1959.** Fluctuations in the Catches of some Pelagic Fishes in Marmara and Black Sea. Procc.and Techn. papers No. 5 GFCM ROME.
- ARTÜZ, İ. 1959.** Some Observations on the Fluctuations in the Catch of *Sardina pilchardus* in Turkish Waters. F.A.O. Experience papers 11. Roma.
- ARTÜZ, İ. 1963.** Contribution to the knowledge of the biology of the Swordfish (*Xiphias gladius* L.) in the Sea of Marmara. Procc. Gen. Fish. Counc. Medit. Vol. 7. ROME.
- ARTÜZ, İ. and KORKMAZ, K. 1976.** Haliç Kirlenmesinde Su Hareketlerinin Rolü. I.B.U. Haliç Sempozyumu İSTANBUL
- ARTÜZ, İ. and KORKMAZ, K. 1978** Marmara Denizinde 1978 Şubat Döneminde Yapılan Hidrografik çalışmalar ön raporu. H.B.A.Enst. Su Kirlenmesi Kısım, İSTANBUL.
- ATLI, M. 1960.** Further information on the Biology of *Scomber colias* Rap.et Proc. Verb. Vol.15.Monaco.
- ATLI, M. ERMAN, F. 1961.** On the Biology of Sardine *Sardina pilchardus* in the Sea of Marmara. Proc. Gen. Fish. Coun. Medit. Vol 6.
- AYDIN YAZICI, S. and ÖKER, A. 1960.** Boğaziçi ve Civarı Dalyanları Hakkında Tetkikler. Balık ve Balıkçılık Mec. Cilt 8. Sayı 7 - 8 EBK İSTANBUL.
- BACESCO, M. C. ET MARGINEANU, C. 1959.** Elements mediterranees nouveaux dans la faune de la faune de la mer Noir,recolte dans les eaux de Roumelie (Nord-Ouest-Bosphore)Archivio di Oceanogr. e Limn. Vol.XI. Venezia.
- BINI, G. 1970.** Atlate dei pesci delle Coste Italiane. Mondo Sommerso editrice s.r.l. Roma.
- BODEANU, N. 1961.** Contribution a l'etude des Diatomees Benntiques du littoral Roumain et Prebosphorique. Rapp. C.I.E.S.M. Vol. XVI. Fasc. 2,p. 441.
- CASPERS, H. 1968.** La Macrofaune du Bosphore et les Problemes de l'infiltration des elements Meditteranees dans la Mer Noire. Rapp. C.I.E.S.M. Vol. XiX.Fasc. 2. p.107-115
- DAMOC, 1971.** Master Plan and Feasibility Report for Watersupply and Sewerage for the Istanbul Region. Prepared for WHO - UNDP. Los Angeles, California USA.
- DEMİR, M. 1952-1954.** Boğaz ve Adalar Sahillerinin Omurgasız Dip Hayvanları. Pub. Hyd. Res. Inst. Univ. Of Istanbul. Series A. No: 3. Istanbul.
- DEMİR, M. 1954.** Report on the Plankton of the South Eastern Coast of the Black Sea. Pub. Hyd. Res. Inst. Univ. of Istanbul. Series B,Vol.I.Fasc.4. pp. 284-286. İstanbul.
- DEMİR, M. 1955.** Deniz supireleri (Cladocera) ve bunların Karadeniz sahil sularımız ile Marmarada bulduğumuz neveleri. Hidrobiol. Seri A. Cilt:III, sayı 4.
- DEMİR, M. 1958-1959.** Marmara ve kuzey Karadenizin Pelajik Kopepodları.(Copepoda) faunası. Hidrobiol. Seri A.cilt 4-5 Istanbul.
- DEMİR, M. 1959.** Notes on the littoral penaeidae bate Crustacea-Decapoda of the Turkish Waters. Proc.Gen.Fish.Coun.Medit. Vol.5. Roma

- DEMİR, M. 1960.** Contribution to the knowledge of “*Trachurus*” of the Marmara and the Black Sea. Comm. Int. Expl. Sc. de la Mer. Medit. Proces-verbaux Vol.15.
- DEMİR, N. 1957.** Marmara ve Karadenizde bazı kemikli balıkların yumurta ve larvalarının morfolojileri ile ekolojileri. Hidrobiol. Seri A.Cilt IV. İstanbul.
- DEVECİYAN, K. 1915.** Balık ve balıkçılık. İstanbul
- DEVECİYAN, K.1926.** Peche et pecheries en Turquie. İstanbul.
- DEVLET İSTATİSTİK Enst.** Su ürünleri istatistik anket sonuçları.
- EHRENBAUM, F. 1918-1919.** Über die Seefisherei in Osmanischen Gewaessern. Die Fischerboten. Hamburg IX-X.
- ERAZİ, R. A. R. 1941.** Boğaziçi ve Marmara balıkları. İst. Üniv. F. Fak. Mec. Seri B, cilt:7, sayı:1-2.
- KOSSWIG, C. 1939.** Faunengeschichte der Bosphorus region. C. R. ann.et arch. Soc. Turque. Sc. phys. et nat. Faasc.7.
- LAEVASTU, T. and HELA, I. 1970.** Fisheries Oceanography. Fishing News (Books) LTD. LONDON
- NINNI, E. 1903.** Primo contrubito allo studio dei Pesci e della pesce nelle acque dell impero Ottomano, Venezia.
- NOODT, W. 1955.** Marmara denizi Harpacticoid'leri (Crust.-Cop.)F. Fak.Mec. seri:B, cilt:20 s.49.
- NÜMANN, W.1954.** Croissance et migration des Pelamides (*Sarda sarda*) dans les eaux de la Turquie. C.G.P.M. Doc.de Travail. 3. Reunion Doc. 42. Roma.
- PEKTAŞ, H. 1954.** Uskumruların muhtelif muhaceret sebepleri ve bu konuda muhit suhnetinin rolü. Hidrobiol. Seri A,cilt II. İstanbul.
- RULLIER, F.1963.** Les annelides polychetes du Bosphore,de la Mer de Marmara et de la mer Noir,en relation avec celle de la Mediterranee. Comm.Int.Expl.Sci.mer Medit. Rapp.et Proc.Verb. 17 (2).
- SCULKA,V. H. 1960** Donnees sur la phytoplanton des parages prebosphoriques de la mer Noir. Rapp. et Proc. Verb Comm .Int. Exp. Sci. Mer Medit. Vol 16 (2).
- SLASTENENKO, E. 1956.** Karadeniz havzası balıkları.(The fishes of the Black Sea basin). EBK. Um. Md. yayınlardan. İstanbul.
- SLASTENENKO, E.1938.** Fishes of the Marmara Sea. Works of the Arnoldi Biol.St.Novorossjisk.II.
- TOLMAZIN, D. 1985.** Relative Effects on the Oceanography and Ecology of the Black Sea due to ongoing Soviet River Flow Modifications and the Bosphorus Tunnel Project. Preliminary report submitted to Parsons-Brinckerhoff INC.
- TORTONESE, E. - DEMİR, M. 1960.** The Echinoderm fauna of the Sea of Marmara and Bosphorus. Hidrobiol. seri: B. Vol.5. İstanbul.
- TURGAN, G. 1958.** Lüfer balıklarının yayılış bölgeleri. Balık ve Balıkçılık mec.Cilt VII. İstanbul.
- ZENKEVITCH, L. 1963.** Biology of the Seas of U.S.S.R. George Allen & Unwin LTD.London.