Shifts in fish ecosystem in the Turkish Seas as inferred statistically

F. Bingel, E. Mutlu, A. C. Gücü

bingel@ims.metu.edu.tr; mutlu@ims.metu.edu.tr; gucu@ims.metu.edu.tr
Institute of Marine Sciences-Middle East Technical University, P.O.B 28; TR 33731 Erdemli, Mersin/Turkey

Abstract- In the last few decades, shifts in the trophic states of various aquatic environments have been experienced. This phenomenon is studied from different angles for the world oceans. Recent investigations for the phytoplankton blooms in the seas surrounding Anatolia revealed the progress of eutrophication. The question forwarded in this contribution is whether statistical analysis of a long-term catch data of the Turkish commercial fishery will reflect any signs of change in the ecosystem's trophic state. To overview the fishery and the recent state of the ecosystem, multi-variate statistical analyses were applied to the commercial catch data collected between 1968 and 1999. The emphasis was given to the question to which direction the fish ecosystem was aiming. Related literature on this subject reveal a significant shift towards eutrophication in the seas surrounding Turkey, and this was also reflected in the proportions of the commercial fish.

Keywords- Fishery, Turkish seas, ecosystem shift

Introduction

Depending upon the conditions prevailing in the last few decades, shifts in the trophic states of various aquatic environments have been experienced. This phenomenon is studied from different angles for the world oceans. One of the recent investigations was abstracted by Moncvheva et al., (1999) for the phytoplankton blooms in the Black Sea and the Mediterranean Sea to evaluate the progress of eutrophication. The question put forward here is whether statistical analysis of a long-term catch data of the Turkish commercial fishery will reflect any signs of change in the ecosystem's trophic state.

Materal and Methods

In order to overview the fishery and the recent state of the ecosystem, multi-variate statistical analyses were applied to the commercial catch data collected between 1968 and 1999 by the State Institute of Statistics of Turkey. Emphasis was given to the question to which direction the fish ecosystem was aiming. In this study all Seas around Turkey; NE-Mediterranean, eastern Aegean, Marmara and the southern Black Sea were analyzed. Due to differences in fishing activities the southern Black Sea was considered in two parts, the western and the eastern Black Sea. The catch data were first standardized and, subjected to double-square root transformation in order to level off the significant differences among the various fishing efforts and catches of different species over the years. Hence, the influences of the fishing effort and the overriding effects of the dominant species over the rest of the data were disregarded. Then Cluster and Multi-Dimensional Scaling (MDS) analyses were applied to Bray-Curtis similarity index.

Results

Results are presented on the basis of the seas. For all seas around Anatolia the MDS analysis result applied to Bray-Curtis similarity indices are given (Fig. 1). This is followed by the list of genera contributing to the main catch and top contributing genera (Table 2). Discriminating species between groups formed were presented in Table 2.

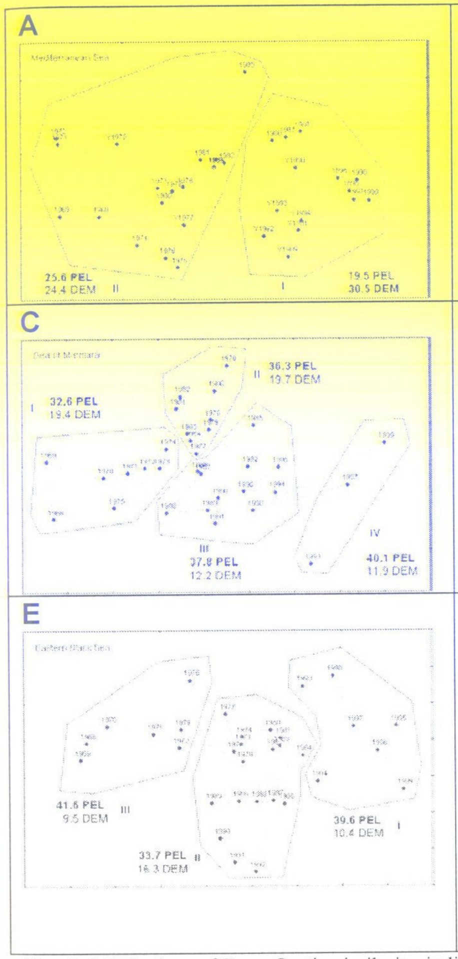
In the Mediterranean Sea the fish-ecosystem was initially demersal oriented, and later has turned in slightly to the pelagic (Fig. 1A). Throughout the study period the main genera contributed to the main catch were *Spicara, Saurida, Mugil* and *Sardine* (Tab. 1A) while discriminating species were *Sphyraena, Scomber, Saurida* etc., (Tab. 2A).

In the Aegean Sea almost the same trend was observed with an intermediate semi-pelagic phase (Fig 1B). The change(s) in this ecosystem occurred in back and forward jumps (higher Multi-Dimensional Scaling distances) as compared with the Mediterranean Sea. In this sea the main contributor to the catch were *Diplodus, Mugil, Boops, Sardine, Merluccius* etc., (Table 1) and the discriminating genera were *Sphyraena, Scomber, Sardine, Merluccius* etc., Table 2B).

The Multi-Dimensional Scaling configuration formed for the Marmara Sea is rather complex and not resembled the Aegean. The Marmara Sea's fish eco-system was already pelagic oriented and this was more pronounced in recent years (Fig. 1C). In this sea the main contributor to the catch were *Mullus, Engraulis, Scomber, Mugil, Sarda, Sardine, Trachurus, Pomatomus* etc., (Table 1C). The groups formed were discriminated by genera like *Scomber, Sarda, Merluccius, Pomatomus, Boops* etc., (Table 2C).

Fishery in the southwestern Black Sea was demersal in the early years (1968-1971). This characteristic shifted towards pelagic (1972-74) and became more noticeable in 1975-1977. Between 1978-1988 for a period of a decade although the system remained its pelagic character, there was a slight inclination towards the demersal and the system seems to be balanced in semi-pelagic - pelagic condition (Fig. 1D). Some of the genera contributed much to the main catch were *Raja, Sarda, Mullus, Engraulis, Scopthalmus, Pomatomus, Trachurus, Mugil, Merlangius etc.,* (Table 1D). Few of the discriminating genera were *Oblada, Zeus, Squalus, Thynnus, Squatina, Boops* etc., (Table 2D).

In the southeastern Black Sea the pelagic fish-ecosystem was dominant in the early years and seems to be well balanced and remain in pelagic state throughout the study period (1968-1999, Fig. 1E). The main contributor to the commercial fish catch were formed by genera like *Trachurus, Sarda, Merlangius, Engraulis* etc., (Table 1E) and some of the discriminating genera were *Mullus, Sarda, Scomber* and *Trachurus* (Table 2E).



Statistical tests revealed that the data in all groups (I, II, III, IV and V) has random distribution and by

A) t=4.76 & p<0.05 groups (I & II) are formed by different populations (diff. pop).
B) t=33.47 & p<0.05 groups (I & II) and t=6.26 & p<0.05 groups (II and III) are formed by diff. pop.
C) t=30.0 & p<0.05 groups (I & II) and t=16.82 & p<0.05 groups (II & III) and t = 60.95 & p<0.05 groups (III & IV) are formed by diff. pop.
D) t=58.05 & p<0.05 groups (I & II) and t=51.56 & p<0.05 groups (II & III) and t=23.78 & p<0.05 groups (III & IV) and t=37.47 & p<0.05 groups (IV & V) are formed by diff. pop.
E) t = 43.47 & p<0.05 groups (I & II) and t=34.7 and p<0.05 groups (II & III) are formed by diff.pop.

Fig. 1: MDS plots of Bray-Curtis similarity indices of standardized catch data. Values in the cells (e.g., PEL & DEM) indicate % proportion of fish species in 50 % similarity.

Note: **B-** Yield of the year 1985 is dominated again by pelagic species (*Sphyraena*), distorting again the overall system picture while the contribution of demersal catch was also increased.
D- Yield of single pelagic species (*Engraulis*) in the year 1989, 90 is extremely low and unexpectedly high in 1993, distorting the overall system picture.

Discussion

In a recent study examining solely the list of fish species found in the Turkish seas, Bilecenoğlu and Taşkavak (2001) characterized the fish fauna of the Turkish Seas as Atlanto-Mediterranean, mainly consisting of medium sized species inhabiting benthic habitats at 0-250m depths. However, considering the statistical evidences abstracted above one may conclude that within the past 30 years (1968-1999) the proportion of the pelagic fish in the total catch is increasing, further indicating that the production in the lower trophic levels was enhanced during the study period. Indeed, the examination of relevant literature allow to underline that the eutrophication processes at the end of the 20[th] Century increased at considerable scales.

Table 1: List of genera contributing to the main catch and top contributing genera (bold).

A- Turkish Mediterranean Sea.

I (1968-1985)		II (1986-1999)	
Spicara	***Saurida* D**	*Mugil*	***Sardine* P**
Pagellus	***Epinephelus* D**	*Mullus*	***Scomber* P**
Squalus	***Mugil* SP**	*Lichia*	
Sarda	***Mullus* D**	*Sparus*	

B- Turkish Aegean Sea.

(I) 1968-1972, 1974-75		(II) 1973, 1976-78, 1980-84, 86-88[a, b)]		(III) 1989-1999	
Diplodus	***Mugil* SP**	*Boops*	***Sardine* P**	*Merluccius*	***Sardine* P**
Sparus	***Sardine* P**	*Mullus*	***Trachurus* P**	*Boops*	***Mugil* SP**
Sarda	***Trachurus* SP**	*Scomber*	***Mugil* SP**	*Mullus*	***Scomber* P**
Boops	***Mullus* D**	*Sarda*		*Trachurus*	***Engraulis* P**

C- The Sea of Marmara

(I) 1968-1975		(II) 1976-1984	
Mullus	***Engraulis* P**	*Scomber*	***Engraulis* P**
Mugil	***Sarda* P**	*Sardine*	***Trachurus* P**
Squalus	***Trachurus* SP**	*Mullus*	***Pomatomus* P**
Spicara	***Sardine* D**	*Mugil*	
Merlangius	***Pomatomus* P**	*Merlangius*	
(III) 1985-1992, 1994-96, 1998		**(IV) 1993, 1997, 1999**	
Pomatomus	***Engraulis* P**	*Merluccius*	***Engraulis* P**
Sarda	***Trachurus* SP**	*Scomber*	***Sardine* P**
Merlangius	***Scomber* P**	*Trachurus*	
Mugil	***Sardine* P**	*Mugil*	

D- South-western Black Sea (Yield of single pelagic species (*Engraulis*) in the year 1989, 90 is extremely low and unexpectedly high in 1993, distorting the overall system picture).

(I) 1968-1971		(II) 1972-1974	
Raja	***Sarda* P**	*Mullus*	***Engraulis* P**
Mugil	***Engraulis* P**	*Mugil*	***Sarda* P**
Scopthalmus	***Pomatomus* P**	*Pomatomus*	***Scopthalmus* D**
Squalus	*Trachurus* **SP**	*Merlangius*	
(III) 1975-1977		**(IV) 1978-88, 1991-92, 1994[a)]**	
Scopthalmus	***Engraulis* P**	*Pomatomus*	***Trachurus* SP**
Merlangius	***Trachurus* SP**	*Merlangius*	***Engraulis* P**
Mugil	***Pomatomus* P**	*Scomber*	***Sarda* P**
Mullus	***Scomber* P**	*Squalus*	
(V) 1995-1999			
Mugil	***Engraulis* P**		
Pomatomus	***Trachurus* SP**		
Scopthalmus	***Merlangius* D**		
Squalus	***Sarda* P**		

E- South-eastern Black Sea.

(I) 1968-72, 75, 79		(II) 1973-74, 76-78, 80-92		(III) 1993-99	
Trachurus	*Engraulis* P	*Trachurus*	***Engraulis* P**	*Merlangius*	***Engraulis* P**
Sarda		*Merlangius*		*Scopthalmus*	
Merlangius		*Sarda*		*Mugil*	

Table 2: Discriminating species between groups.

A) In the Turkish Mediterranean Sea

I and II

Species	Dissimilarity	Ratio (dissimilarity/sd)
Sphyraena sp.	0.76	2.29
Scomber sp.	0.70	2.27
Saurida sp.	0.67	1.68
Sardina sp	1.68	1.54
Epinephelus sp.	0.62	2.23

B) In the Turkish Aegean Sea

	I and II		II and III	
Species	Dissimilarity	Ratio (dissimilarity/sd)	Dissimilarity	Ratio (dissimilarity/sd)
Sphyraena sp.	0.76	2.29	0.64	3.17
Scomber sp.	0.70	2.27		
Saurida sp.	0.67	1.68		
Sardina sp	1.68	1.54		
Epinephelus sp.	0.62	2.23		
Merluccius sp.			0.76	1.91
Trachurus sp.			0.49	1.79

C) The Sea of Marmara

	I and II		II and III	
Species	Dissimilarity	Ratio (dissimilarity/sd)	Dissimilarity	Ratio (dissimilarity/sd)
Scomber sp.	0.76	2.08	0.67	1.52
Sarda sp.	0.66	1.16		
Xiphias sp.	0.65	2.06		
Merluccius sp.			0.89	1.37
Pomatomus sp.			0.55	1.58
Atherina sp.			0.52	1.61

III and IV

Species	Dissimilarity	Ratio (dissimilarity/sd)
Merluccius sp.	0.97	1.73
Boops sp.	0.73	2.76
Sarda sp.	0.64	2.09

D- South-western Black Sea

	I and II		II and III	
Species	Dissimilarity	Ratio (dissimilarity/sd)	Dissimilarity	Ratio (dissimilarity/sd)
Oblada sp.	1.25	1.94	1.65	11.16
Zeus sp.	1.07	9.87		
Squalus sp.	0.93	1.37	1.14	1.42
Thynnus sp.	0.85	1.15	1.14	1.61
Xiphias sp.	0.85	1.29		
Sparus sp.	0.84	1.52		
Lichia sp.			0.97	1.31

Table 2-D cont.

Species	III and IV Dissimilarity	III and IV Ratio (dissimilarity/sd)	IV and V Dissimilarity	IV and V Ratio (dissimilarity/sd)
Squalus sp.	1.22	1.51		
Thynnus sp.	1.12	1.59		
Squatina sp.	1.10	2.75		
Oblada sp.	1.04	1.86	0.98	1.88
Zeus sp.			1.13	3.67
Boops sp.			0.97	1.84

E- South-eastern Black Sea

Species	I and II Dissimilarity	I and II Ratio (dissimilarity/sd)	II and III Dissimilarity	II and III Ratio (dissimilarity/sd)
Mullus sp.	1.21	1.74	1.25	1.67
Sarda sp.	1.12	1.71		
Scomber sp.	1.02	2.03		
Trachurus sp.			1.93	2.37
Pomatomus sp.			1.25	1.63
Squalus sp.			1.19	2.15

Related literature (in the Turkish Med., Yılmaz et al., 1997 & 2001 and Çoban-Yıldız et al., 1999; in the Aegean Çoban-Yıldız et al., 1999, Giannakourou and Pitta, 1999, Tselepides et al., 1999; in the Sea of Marmara Ertürk et al., 2001, Çoban-Yıldız et al., 1999, Polat et al., 1999; in the Black Sea Cociasu et al., 1996, Mee, 1997, Humborg et al., 1997, Çoban-Yıldız et al., 1999, Konovalov et al., 1999, Yılmaz et al., 1999) showed a significant shift towards eutrophication in these seas surrounding Turkey, and this was also reflected in the proportions of the commercial fish landings. Interesting points to be underlined here are the situations in the Turkish Mediterranean Aegean and southwestern Black Sea. It is generally assumed that especially the Mediterranean Sea is oligotrophic and mostly demersal in nature as claimed by Bilecenoğlu and Taşkavak (2001). However long term catch data and a few recent investigations indicate considerable nutrient loads. Thus causing a shift of the fish community structure (at least for the coastal areas) from demersal to pelagic forms. Turkish Mediterrenean, Aegean and southwestern Black Sea are suspected to a shift from demersal to semi-pelagic or pelagic while other sea areas remain at their earlier state.

References

Bilecenoğlu, M., Taşkavak, E. "Türkiye deniz balıkları faunasına istatistiksel bir yaklaşım". XI. Ulusal Su Ürünleri Semp. 4-6 Eylül 2001, Hatay, pp 480-485, (2001).

Çoban-Yıldız, Y., Tuğrul, S., Polat, Ç., Ediger, D., Yılmaz, Y., Fabbri, D. "A comparative study on the abundance and elemental composition of seston in three interconnected basins: The Black, the Marmara and the Mediterranean Seas". Internat. Conf., Oceanography of the Eastern Mediterranean and Black Sea, 23-26 February 1999, Athens, abstract, pp. 11-12, (1999).

Cociasu, A., Dorogan, L., Humborg, C., Popa, L. "Long-term ecological changes in Romanian coastal waters of the Black Sea". Mar. Pollution Bull. 32(1): 32-38, (1996).

DIE, "Fishery Statistics. State Institute of Statistics". (1968-1999).

Ertürk, A., Fındık, N., Kınacı, C. "Denizlerin kıyı kısımlarının ötrofikasyon tehlikesi açısından değerlendirilmesi". IV. Ulusal Çevre Müh. Kongresi 1-10 Kasım 2001-İçel, poster, pp 552-555, (2001).

Giannakourou, A., Pitta, P. "Ciliated protozoa in the oligotrophic north Aegean Sea". Internat. Conf., Oceanography of the Eastern Mediterranean and Black Sea, 23-26 February 1999, Athens, abstract, pp. 236, (1999).

Humborg, C., Ittekkot, A. C., V. Bodungen, B. "Effect of Danube River dam on Black Sea biogeochemistry and ecosystem structure". Nature 386: 385-388, (1997).

Konovalov, S. K., Ivanov, L. I., Murray, J. W., Eremeeva, L. V. "Eutrophication: A plausible cause for changes in hydrochemical structure of the Black Sea anoxic layer". In: Environmental Degredation of the Black Sea. Challenges and Remedies, Beşiktepe et al., (eds), Kluver Acad Publ. pp. 61-74, (1999).

Mee, L. D. "The Black Sea: A continuing cause for concern". With rivers to the sea. Joint Conference, 7th Stockholm Water Symposium 3rd Internat. Conf., on the Envir., Management of Enclosed & Coastal Seas (EMECS) 10-15 August 1997, Stockholm, abstract, pp 22-25, (1997).

Moncheva, S., Gotsis-Skretas, O., Pagou, K., Krastev, A. "Phytoplankton blooms – A key ecological issue in Black Sea and Mediterranean coastal ecosystems: Similarities and differences". Internat. Conf., Oceanography of the Eastern Mediterranean and Black Sea, 23-26 February 1999, Athens, abstract, pp. 26-27, (1999).

Polat, S. Ç., Tuğrul, S., Baştürk, Ö., Salihoğlu, İ. "Oceanography of the Marmara Sea: Bio-chemical features". Internat. Conf., Oceanography of the Eastern Mediterranean and Black Sea, 23-26 February 1999, Athens, abstract, pp. 99, (1999).

Tselepides, A., Duineveld, G., Danovaro, R., Chrinis, G., Wassmann, P. "Pelagic-benthic coupling in the oligotrophic Cretan Sea". Internat. Conf., Oceanography of the Eastern Mediterranean and Black Sea, 23-26 February 1999, Athens, abstract, pp. 272-273, (1999).

Yılmaz, A., Salihoğlu, İ., Tuğrul, S., Baştürk, Ö. "Pollution loads from land-based sources of Turkish Mediterranean coast and their impacts on the marine environment". With rivers to the sea. Joint Conference, 7th Stockholm Water Symposium 3rd Internat. Conf., on the Envir., Management of Enclosed & Coastal Seas (EMECS) 10-15 August 1997, Stockholm, abstract, pp 165-167, (1997).

Yılmaz, A., Yayla, M., Çoban-Yıldız, Y., Tuğrul, S., Salihoğlu, İ. "Nutrient availability and the dynamics of the plankton production in the southern Black Sea, the Sea of Marmara and the northeastern Mediterranean". Internat. Conf., Oceanography of the Eastern Mediterranean and Black Sea, 23-26 February 1999, Athens, abstract, pp. 42-43, (1999).

Yılmaz, A., Yemenicioğlu, S., Salihoğlu, İ., Tuğrul, S. "Doğu Akdeniz ekosistemi ve deniz kirliliğnin ekosistem üzerindeki etkileri". IV. Ulusal Çevre Müh. Kongresi 1-10 Kasım 2001-İçel, pp 347-355, (2001).