

Therefore, estimation of the total losses due to all fisheries is of importance for management purposes.

Difficulties involved in determining the age of the fish have been discussed by several authors (Pauly, 1982; Sparre, 1987; Sparre et al., 1989) and there is an increasing tendency, especially within tropical waters, to use length–frequency data rather than age determination. Parallel to the vast expansion of personal computers, many computer packages have been available to fishery scientists. The model developed here therefore utilizes length–frequency data of two successive trawl surveys, and can be used in conjunction with well-known commercial computer programs such as LFSA, ELEFAN, and FISAT (Sparre, 1987; Gayanilo et al., 1988).

STATE OF THE STOCKS

The richness of the fishing grounds in the study area, relative to the Mediterranean standard, was discovered during the 1940s. In the early 1950s, Kosswig (1953) ranked the Gulf of Iskenderun amongst the most productive fishing resources of the Mediterranean Sea. Turkish fishermen have exploited the stocks in the gulf since Turkey gained sovereignty of the Iskenderun province. In 1940, there were only two trawlers operating in the region, a number which had increased to fourteen by 1952 (Aasen and Akyuz, 1956). The rapid increase in fishing effort during the early fifties generated the first symptoms of over-fishing in 1954 (Aasen and Akyuz, 1956). Since then, the number of boats has increased dramatically and Bingel (1981) reported nearly 60 trawlers in the region during the 1980 fishing season. Today, there are nearly 200 trawlers operating along the Mediterranean coast of Turkey (Anon, 1993). It is obvious that stocks of the region are under heavy pressure from fisheries.

HYDROGRAPHY AND FISH COMMUNITY

The area in which the fish stocks have to be assessed is quite large (4535 km²) and falls within the 100 m isobath from Göksu to the easternmost point of the Iskenderun bay (Fig.1). Topographic structures suggest the probable occurrence of independent stocks in the region because of the distinct geographic location of the Gulf of Iskenderun (Fig.1). However, apart from such short-term exceptions as the generation of gyros within the Gulf of Iskenderun in midsummer, the general hydrographic characteristics are mainly determined by the Levantine circulation system prevailing just outside the bay (Latif et al., 1989). The minimum and maximum current meter readings obtained in the different regions of the Gulf of Iskenderun, were reported as 1.5 and 51.5 cm/s and 1.5 and 38.0 cm/s in November–December 1988 and August–September 1989, respectively, which indicates fairly dynamic water transfer between the Gulf of Iskenderun and Mersin Bay.

For the purposes of this study, the community included in the box model is assumed to form a self-contained system. This assumption, though questionable, is supported by the following evidence:

First, the continental shelf is very narrow and there is only a very narrow infralittoral zone along the west side of the Göksu River. This is mostly rocky and is not a suitable habitat for the fish species included in this study (Fig. 1). In this sense, there is a narrow

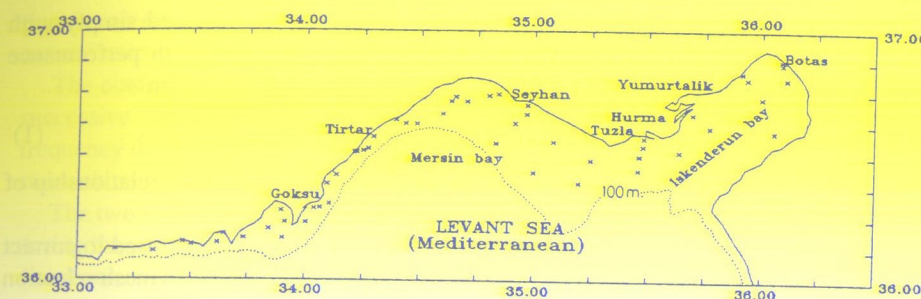


Fig. 1. Study area and position of the trawling stations.

bridge, which limits, to a great extent, the passage of the bottom-dwelling demersal fishes further west. This is more obvious for such Red Sea immigrants as *Leiognathus klunzingeri*, *Saurida undosquamis*, and *Upeneus moluccensis*, which have formed a considerable local population within the study area and apparently cannot exceed Cape Anamur (Gücü et al., 1994).

Secondly, under the hydrographic situation described above (one-way flow of the water masses under the influence of the main Levantine current), eggs and larvae may be transported in the western direction, but since the bottom is not suitable for settlement, mixing with adjacent waters is probably insignificant.

DATABASE AND METHODS OF ANALYSIS

FISHERIES DATA

Sampling was spread over a 5-year period which can be divided into two parts. In the first part (May 1980–November 1982), samples were collected at monthly intervals (28 cruises) and the total study area was represented by seven regions (Göksu, Tirtar, Seyhan, Tuzla, Hurma, Yumurtalik, and Botas, see Fig. 1). In each cruise, to minimize sampling error and to obtain representative data, four trawl hauls from different depths (0–10 m, 10–20 m, 20–50 m, and 50–100 m) were taken from each region, weather conditions and other circumstances permitting.

During the second sampling program (1983–1984), samples were collected twice a year to estimate the trawlable fish biomass. In order to increase the area coverage and hence to improve the reliability of the samples, the number of hauls in each stratum and subregion was increased and 52 stations were sampled in each survey (Fig. 1).

Growth parameters L_{∞} and K were derived from the seasonally oscillating von Bertalanffy Growth Function, VBGF (Pauly and Gaschult, 1979; Somers, 1988). The long-time series of length–frequency data (28 months), collected during the first sampling program mentioned above, was used as input to the Compelet ELEFAN Program, Ver. 1.11 (Gayanilo et al., 1988), and all growth parameters were established by running the ELEFAN I routine. The L_{∞} (asymptotic length) and K (growth coefficient per year)

of the VBGF are mutually related parameters and cannot be compared simply with parameters estimated elsewhere. To facilitate comparisons, the growth performance index ϕ' proposed by Munro and Pauly (1985) was computed in the form

$$\phi' = \log K + 2 \log L_{\infty} \quad (1)$$

The instantaneous natural mortality rate (M) was estimated from the relationship of growth parameters and temperature to M described by Pauly (1980).

Selection ogives were estimated using the ELEFAN II program and used to correct those parts of the length–frequency distributions which were subjected to mesh selection and incomplete recruitment (Pauly, 1983b; 1984a, 1984c).

Food preferences and prediction of food consumption rates (Q/B) by each species included in the model are the most important requirements of the trophic ecosystem model. When these are known it becomes possible to link the model's compartments.

During the second sampling period (1983–1984) the stomachs of all predator species were fixed by immediate formalin injection at capture and were examined. The number and individual biomass of prey items were measured. Samples with a stomach showing any indication of regurgitation (such as a loose shape) were excluded. Food preferences were calculated from stomach content analysis and presented in the form of a food preference matrix. The ratio of food consumption to the biomass of the consumers (Q/B) during the stated periods was estimated by the empirical model of Palomares and Pauly (1989).

$$\ln(Q/B) = -0.1775 - 0.2018 \ln W_{\infty} + 0.6121 \ln T + 0.5156 \ln A + 1.26 FT \quad (2)$$

where Q/B is the daily food consumption of a fish population as a percentage of its biomass, W_{∞} is the mean asymptotic (or maximum) biomass (g), T is mean habitat temperature ($^{\circ}\text{C}$), A is the aspect ratio of the caudal fin, and FT is the food type (here coded either '0' in carnivores or '1' in herbivores).

DESCRIPTION OF THE NUMBER-BASED BOX MODEL

The model developed in this study was not intended to derive equations new to fishery science, but rather to utilize various forms of the well-known fish population dynamics equations in various ways. The method derived here was inspired by Russell's (1931) classic axiom. The original version of Russell's axiom was based on biomass differences in time. For computational purposes, biomass in the equation was replaced by abundance. Since growth in biomass will have no effect on the number of individuals (abundance) in the stock, Russell's equation becomes

$$N_2 = N_1 + R - (M + Y) \quad (3)$$

where N_1 and N_2 are, respectively, the total number of individuals of the exploited phase of the fish stock at the beginning and end of a given time period, R is the recruitment to the exploited phase, M is the number of fish that died due to natural causes, and Y is the yield or catch between two successive time periods. In this context the population is defined as a closed system without any emigration and immigration. Increases in

population only occur due to recruitment, and reduction is due to fishing removal and natural mortality (Ricker, 1975; Pauly, 1984b).

The computational steps are depicted in Fig. 2. The inputs to the model are (1) two successive estimates of the number of individuals in the stocks and their length–frequency distributions, and (2) the predator food preference matrix computed from the stomach contents of each species.

The two input boxes in Fig. 2 (N_1 and N_2) are obtained from trawl surveys carried out during the second sampling program (1983–1984). In the first step the length–frequency distributions of the species obtained from different trawl hauls were standardized to uniform trawling time and then pooled.

It is assumed that stocks are distributed uniformly within each predefined depth stratum, and that length–frequency distributions obtained by the method are thought to represent those of the whole stock. Hence, the length–frequency distributions could be extrapolated to the whole region by applying the same principles of the stratified swept-area method first described by Saville (1977).

The values obtained by swept-area methods are not representative of the stock, since the trawl net is selective over small size groups. Therefore, in order to compute the true size structure of a fish stock it was necessary to take the effect of selection and

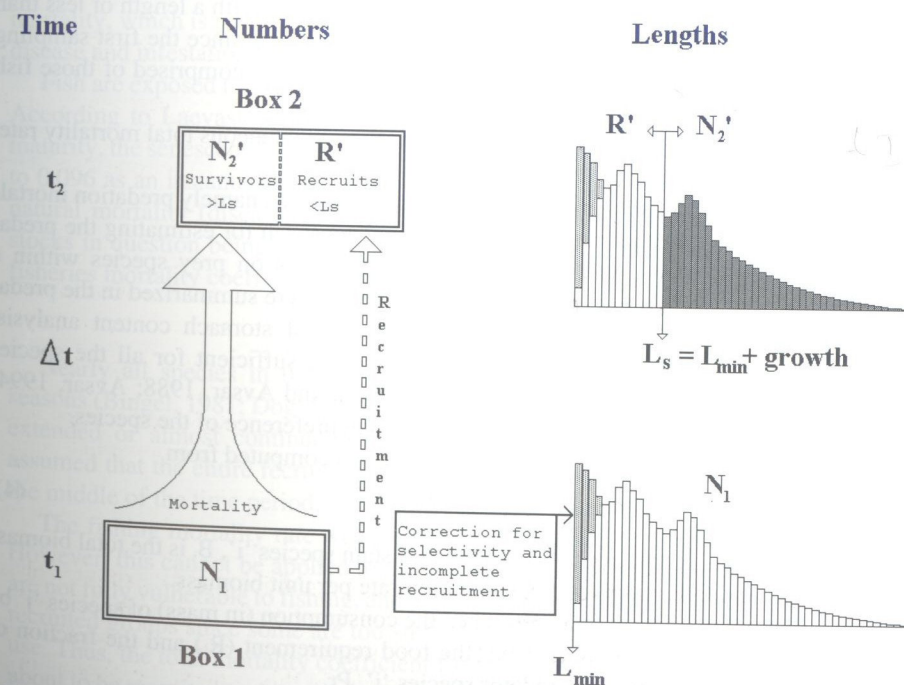


Fig. 2. Schematic representation of the model.

incomplete recruitment into account. Length–frequency data were therefore corrected for the selected smaller length groups using probability of capture data produced from selection ogives (Pauly, 1986).

The corrected data were still not fully representative of the whole stock because there were more length classes below the minimum observed which were not available to the fishery. However, since the model represents the exploited phases of the stock, the numbers in very small length groups which were not included in the data were omitted.

After these corrections, the data were assumed to consist of absolute numbers representing all size groups vulnerable to the trawl fishery.

In the model the exploited fish stock is considered as a pool with continual inflows and outflows. The numbers (N_1) estimated at time ' t_1 ' will therefore decrease due to mortality and will increase due to recruitment (eq 3). The numbers (N_2) at time ' t_2 ' consist of two components; (i) individuals which have reached the full exploitation size during the first period and which could survive thereafter; this is the surviving part of box N_1 (Fig. 2), and (ii) survivors of the recruits which became vulnerable to fishing during the period (t_2-t_1). These are the newly added components of the box since the first period.

The length of fish growing to a length L_{rec} from the smallest length L_{min} in box N_1 was computed from von Bertalanffy's equation (1938). Those fish in box N_2 with lengths smaller than L_{rec} were assumed to be new recruits. In this way it was possible to separate box N_2 into two components, namely the total number of fish with a length of less than L_{rec} , comprised of the number of recruits, R' , joining the stock since the first sampling period and the number of fish, N_2' , of length greater than L_{rec} , comprised of those fish that survived since the first sampling period.

After estimating the total number of survivors, the instantaneous total mortality rate, Z , was estimated from the survival rate (N_2'/N_1).

The natural mortality was divided into two compartments, namely predation mortality and mortality from other causes. The numerical approach for estimating the predation mortality was based on the dependence of predators on prey species within a multispecies complex. Thus diet and food requirements were summarized in the predation matrix which was constructed using the results of stomach content analysis. However, the data collected for this analysis were not sufficient for all the species groups considered, and the relevant literature (Bingel and Avsar, 1988; Avsar, 1994) had to be used to fill the information gaps in the food preference of the species.

The total biomass required to sustain a species was computed from

$$R_i = Q/B \cdot B_i \quad (4)$$

where R_i is the total amount of food needed to sustain species ' i ', B_i is the total biomass of species ' i ', and Q/B is the food consumption rate per unit biomass.

The consumption of each food item, i.e., the consumption (in mass) of species ' j ' by species ' i ' (UW_{ij}), was computed from the food requirement (R_i) and the fraction of species ' j ' (prey) in the food of predator species ' i ', Pr_{ij}

$$UW_{ij} = R_i \cdot Pr_{ij} \quad (5)$$

The UW_{ij} were expressed in biomass; however, what is important for the model is the total number of prey ' j ' consumed by predator ' i ', UN_{ij} . Here it was assumed that for each predator there is an optimum size of prey ("Ivlev's principle", Ivlev, 1961); that is, the maximum and minimum prey size that a predator can consume depends on the maximum mouth opening and the operculum apertures of the predator and, hence, each prey item in the stomach of a predator has an average biomass. By dividing UW_{ij} by the average biomass of individual prey ' j ', observed in the stomach of predator ' i ', PW_{ij} , UN_{ij} were approximated.

$$UN_{ij} = UW_{ij}/PW_{ij} \quad (6)$$

The total removal of species ' j ' due to predation becomes

$$Pr_j = \sum_i UN_{ij} \quad (7)$$

The instantaneous predation mortality coefficient (M_p) was computed from

$$M_p = -\ln(1 - Pr_j/N_j) \quad (8)$$

where Pr_j is the number of prey ' j ' consumed by all predators, and N_j is the initial number of species (Laevastu and Larkins, 1981).

The nonpredation mortality consists predominantly of spawning stress or senescent mortality, which is relatively small in long-lived species, together with mortality due to disease and infestation by parasites (Laevastu and Larkins, 1981).

Fish are exposed to senescent mortality only after they have reached sexual maturity. According to Laevastu and Larkins (1981), after the cohort has reached about 80% maturity, the senescent mortality starts to increase by about 10% per year, corresponding to 0.096 as an instantaneous rate per year. Assuming that residual, density-dependent, natural mortality (diseases, parasitic effects, starvation) was at negligible levels, the stocks in question being subjected to heavy fishery (Laevastu and Larkins, 1981), the fisheries mortality coefficient was estimated from the following equation

$$F = Z - (M_p + M_s) \quad (9)$$

Nearly all species in these studies have multiple or at least extended spawning seasons (Bingel, 1981; Dogan, 1983; Bingel, 1988; Gücü, 1991), which in turn suggests extended or almost continuous recruitment throughout the year. Therefore, it was assumed that the entire recruitment could be treated as taking place instantaneously at the middle of the time period, $\Delta t/2$ (knife-edge recruitment).

The fishing mortality rate was assumed constant among the fully recruited groups. However, this cannot be applied to the size group under full vulnerability. The recruits are not fully vulnerable to fishing, and their fishing mortality rate is less than that of fully recruited groups since some are too small to be taken effectively by the fishing gear in use. Thus, the total mortality coefficient for those small groups which are recruited and about to be recruited to the exploited part of the stock was termed Z' . Fish taken into this

category (from prerecruits to postrecruits) had a relatively large range of size and, depending on their size, they were exposed to different levels of fishing mortality. The vulnerability of newly recruited fish gradually increased with their size, each fish becoming more and more likely to be caught as it grew larger and older until the size limit of maximum vulnerability was reached. Fish which have become newly vulnerable to fishery have a total mortality very close to those which only die from natural causes ($F = 0$). The fishing mortality rate increases to the maximum value F parallel to the increase in their body size. During this period the average fishing mortality was between zero and F . Thus, the fishing mortality coefficient of the newly recruited group was assumed to be half of the total fishing effort, and the total mortality for this group was computed using the following equation

$$Z' = M_p + M_s + F/2 \quad (10)$$

In the box N_2 , that portion which was newly recruited can be calculated by summing all individuals whose length was less than the critical value, L_{rec} . However, this represents the fraction of the total recruits joining during the time interval Δt . In order to calculate the actual number of recruits (R), a back-reflection of the recruitment mortality coefficient was applied to the number of recruits remaining, R' .

$$R = R' / (e^{-Z'\Delta t/2}) \quad (11)$$

There were two sources for the catch. One, from adults (C_a), can be estimated by Baranov's (1918) catch equation

$$C_a = N_1 F/Z (1 - e^{-Z\Delta t}) \quad (12)$$

When recruitment occurs abruptly there is little need to worry about the incompletely recruited groups since they form only a small portion of the catch. However, if recruitment extends over a whole year as in the present case, then incompletely recruited groups are not merely important but actually comprise the major part of the catch. Therefore, this part of the total catch was explicitly estimated. This removal from small-sized groups (C_r) was computed from Baranov's equation, the parameters Z and F being replaced by Z' and $F/2$.

$$C_r = R F/2 Z' (1 - e^{-Z'\Delta t/2}) \quad (13)$$

The model described so far was based on numbers, the population being divided into length groups, and the numerical strength of each length group being computed separately. However, the results produced in this manner were not compatible with traditional expressions, especially those of catch statistics, where biomass is used instead of numbers. Numbers have therefore been converted into biomass.

The weight-length relations and the corrected length-frequency distributions were used for number-to-biomass conversion. The mid-points of each length class (L_i) were converted into biomass by length-weight regression and multiplied by the corresponding frequency. The product of all converted values gives the total biomass of the data

$$B = \sum_{i=L_{min}}^{L_{max}} a L_i^b \cdot N_i \quad (14)$$

where, B is the biomass, N_i is the number of individuals in length class 'i', and 'a' and 'b' are regression parameters in the weight/length relationship.

Production from stocks was calculated by utilizing growth parameter estimates. The growth during the period Δt of fish having a length greater than L_{rec} was computed from von Bertalanffy's equation. Length increments were converted into biomass by length-weight regression and multiplied by the number of fish in each length class. The sum of all biomass was utilized as the total body substance \dot{P} produced by the stock via growth. Since exactly one complete year elapsed between the two sampling periods, Δt was equal to 1 year and the results obtained from the following formula are therefore the annual production from the stock.

$$P = \sum_{i=L_{rec}}^{L_{max}} a [L_{\infty} (1 - e^{-K\Delta t} (1 - L_i/L_{\infty}))]^b \cdot N_i \quad (15)$$

Finally, P/B was calculated from the ratio between P and the biomass of the first period.

RESULTS

Primary results, which were later used as the input to the model (growth parameters, L - W relationships, food consumption rates) are given in Table 1. For comparison and for a better interpretation of the VBGF estimates, growth performance indices are also presented.

The stomach content analyses of the predator species are depicted as food preferences in Table 2. The outputs of the model are presented in Table 3. For some species, such as *Saurida undosquamis* and *Zeus faber*, predation mortality could not be estimated

Table 1
Parameters used in the model

Family	Species	L_{∞}	K	ϕ'	a	b	Q/B
Synodonthidae:	<i>Saurida undosquamis</i>	42.80	0.42	2.89	0.0058	3.06	9.55
Merlucciidae:	<i>Merluccius merluccius</i>	49.90	0.35	2.94	0.0018	3.48	5.02
Zeidae:	<i>Zeus faber</i>	58.80	0.24	2.92	0.0091	3.20	4.43
Mullidae:	<i>Mullus barbatus</i>	24.20	0.63	2.57	0.0060	3.25	10.68
Mullidae:	<i>Upeneus moluccensis</i>	25.60	0.43	2.45	0.0043	3.35	12.77
Sparidae:	<i>Boops boops</i>	30.00	0.47	2.63	0.0365	2.55	12.55
Sparidae:	<i>Pagellus erythrinus</i>	34.20	0.40	2.67	0.0146	2.95	11.04
Centracanthidae:	<i>Spicara flexuosa</i>	22.80	0.57	2.47	0.0040	2.54	12.16
Triglidae:	<i>Trigla lucerna</i>	40.00	0.28	2.65	0.0070	3.06	7.94
Citharidae:	<i>Citharus linguatula</i>	28.00	0.52	2.61	0.0031	3.28	9.62
Bothidae:	<i>Arnoglossus laterna</i>	17.00	0.43	2.09	0.0141	2.97	11.03

L_{∞} = Asymptotic length in cm; K = growth coefficient per year; ϕ' = growth performance index; a = intercept and b = slope of the weight-length conversion equation; Q/B = food consumption rate per unit biomass

Table 2

Diet composition of the important predator species of the trawl fishery (%). The numbers in the uppermost row indicate predators as numerically coded in the prey column

Prey species		Predators					
		1	2	3	4	5	6
<i>Merluccius merluccius</i>	(1)		1.16				
<i>Saurida undosquamis</i>	(2)						
<i>Citharus linguatula</i>	(3)			1.71			
<i>Arnoglossus laterna</i>	(4)			1.76			
<i>Trigla lucerna</i>	(5)						
<i>Zeus faber</i>	(6)						
<i>Mullus barbatus</i>		9.08	15.58				30.30
<i>Spicara flexuosa</i>		65.17	16.35	12.29			
<i>Boops boops</i>			1.96				
<i>Upeneus moluccensis</i>			5.48				54.90
<i>Sardinella & Engraulis</i>		21.63	39.59	23.90			
<i>Trachurus trachurus</i>			1.37				
<i>Leiognathus klunzingeri</i>			3.27				
<i>Gobius spp.</i>			8.85	1.04	0.53	12.63	
<i>Trigla spp.</i>				0.88	0.26		
<i>Squilla spp.</i>				0.78		44.84	
Penaeids		1.17		14.05	13.16	17.31	
Digested fish		2.96	6.40	40.18	2.63	0.05	2.07
Other decapods					12.90	2 5.17	
Unidentified				3.42	70.52		12.73

since top predators were outside the scope of this study. Pauly's empirical equation was used for the species, as explained above. The most important findings of the model are depicted in Fig. 3.

DISCUSSION AND CONCLUSION

Though this is not the first time that a study on fish stocks has been attempted on demersal stocks of the northeastern Mediterranean Sea, it is the first to approach the subject from a multispecies point of view.

The trophodynamic complexity of the multispecies system is obvious at first glance (Fig. 3), even though apex predators, such as sharks, sea turtles, dolphins, and other sea mammals remained outside the scope of the study. Although boxes were arranged in such a way as to separate prey and predators, some predators consumed piscivorous species, as in the case of *Saurida undosquamis* and *Merluccius merluccius*. It is therefore difficult to follow the web-like structure of the model (Fig. 3).

Figure 3 indicates some groups to be subjected to the combined effects of high fishing pressure and predation, while others are nearly invulnerable and are not linked to

Table 3
Results of the model

Family / Species	C	Pr	B	P	R	P/B	Y	Z	F	Mp
<i>Synodonthida</i>										
<i>Saurida undosquamis</i>	1085	—	1195	600	485	0.50	2345	2.41	1.55	0.86
<i>Merluccidae</i>										
<i>Merluccius merluccius</i>	579	132	129	111	600	0.86	152	2.77	2.06	0.70
<i>Zeidae</i>										
<i>Zeus faber</i>	8	—	7	4	4	0.57	na	1.89	1.35	0.54
<i>Mullidae</i>										
<i>Mullus barbatus</i>	321	1846	931	389	1178	0.42	1010	2.58	2.08	0.50
<i>Upeneus moluccensis</i>	124	643	55	33	734	0.60	na	1.69	0.89	0.79
<i>Sparidae</i>										
<i>Boops boops</i>	420	224	548	9	635	0.02	159	4.11	3.85	0.26
<i>Pagellus erythrinus</i>	742	—	323	119	622	0.37	395	3.73	2.85	0.89
<i>Centracanthidae</i>										
<i>Spicara flexuosa</i>	66	2484	41	6	2544	0.15	517	3.55	1.08	2.47
<i>Triglidae</i>										
<i>Trigla lucerna</i>	259	—	66	36	223	0.55	34	3.49	2.82	0.67
<i>Citharidae</i>										
<i>Citharus linguatula</i>	638	27	167	91	574	0.54	na	3.16	1.19	1.97
<i>Bothidae</i>										
<i>Arnoglossus laterna</i>	193	28	381	115	106	0.30	na	2.59	0.78	1.81

C = catch estimates; Pr = predation loss; B = biomass; P = production; R = annual recruitment; P/B = production per biomass ratio; Y = annual landings from Anon. (1985); Z, F, Mp = Annual instantaneous total, fisheries, and predation mortality coefficient obtained via model, respectively. Predations in bold are estimated from Pauly's (1980) empiric relation.

the fisheries boxes. The so-called "trash fish", such as noncommercial triglids and crabs, which are grouped under "*Trigla spp.*" and "other decapods", respectively, are among the nonvulnerable groups. Their abundance in the system increases considerably with increasing fishing pressure. Figure 4 illustrates the time series of trash fish (*Trigla sp.*, Other decapods, *Squilla spp.*, *Gobius spp.*), and the other commercially important species. It is apparent that the group, which has no commercial importance and is therefore discarded, is becoming more and more important to the system. This is typical evidence of what is known as "ecosystem overfishing" as described by Pauly (1983a).

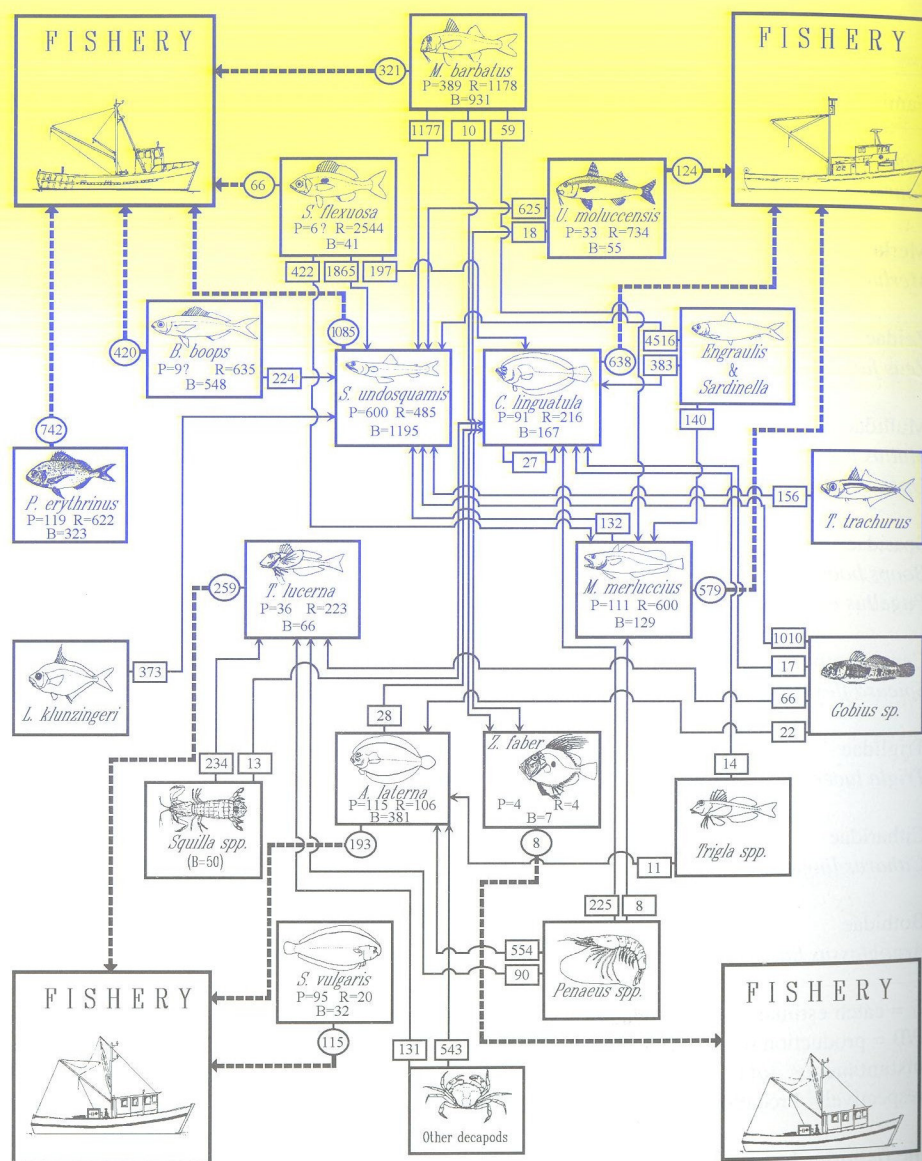


Fig. 3. Results of the box model. B = Biomass; R = Recruitment; P = Production (values are given in tons/year). Six boxes located at the center represent the predators and the surrounding boxes represent the prey. Large boxes at the corners stand for the fishery. Numbers along the arrows connecting predator and prey or fishes to fishery, indicate the flow of biomass between corresponding boxes. For *Spicara flexuosa* and *Boops boops*, production is suspiciously low, and pointed with a "?" in Fig. 3.

Some species in Fig. 3, such as *Solea vulgaris* and *Pagellus erythrinus*, are not connected to predators. These species are important components of the system in terms of their contribution to the total catch. They are also important to the material circulation of the ecosystem through prey-predator relations, although the data are now insufficient to reflect their place in the ecosystem.

The group of fish "*Engraulis & Sardinella*" was probably the most important component of the system. They are pelagic fish seldom observed in the trawl catch. On the other hand, the model indicates 5000 tons of this group to be predated by the trawlable demersal species. This is nearly 40% of the total food predated within the system. It therefore seems that stocks of predators included in the model are vitally dependent on the pelagic fishes grouped under "*Engraulis & Sardinella*". In short, sustainability of the trawl fishery depends on the strength of the small pelagics.

Catches are another output of the model. The results presented in Table 3 are valid only for the northeastern Mediterranean Sea. For some species catch estimates seem relatively high compared with those declared for the entire Mediterranean coast of Turkey (Table 3) by the State Institute of Statistics (Anon., 1985). The discrepancies that exist between estimated and declared catch values stem both from fishery statistics and the model itself. The fishery statistics do not include landings from small-scale artisanal fisheries. Moreover, the terms C (catch estimates) and Y (landings) of Table 3 are not essentially comparable. Catch values estimated by the model include all size groups which die from other than natural causes, whereas the term "landings" includes only fishes above marketable size and not the small size groups which are discarded. This suggests an alternative explanation for the contradiction between estimated catch values and the landings.

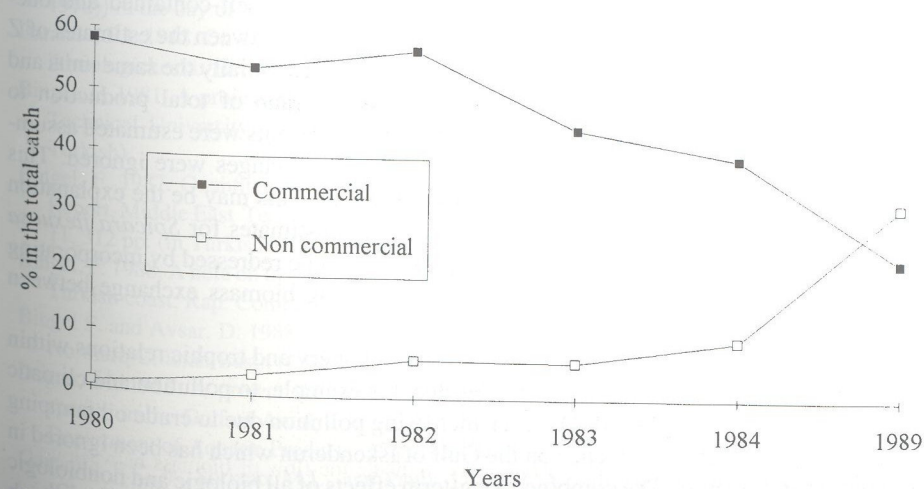


Fig. 4. Percentage of commercial and trash fishes in the Northeastern Mediterranean Sea.

The reliability of the catch estimates largely depends on the accuracy of the predation mortality (eq 9). Predation mortality in the model is due only to the 6 most dominant predator species encountered along the northeastern Mediterranean basin. It is evident that there may be many other contributors to predation losses, which were ignored in the model. The predation mortality may therefore be underestimated and this implies that the catch may be overestimated. In the present study, much emphasis has been paid to predation. The method applied here for the estimation of predation may only be true when the preference indices computed for each species remain constant over the time period under study. However, in such temporally fluctuating ecosystems, as in the area under examination, there are substantial seasonal variations in abundance throughout the year (Bingel, 1987). This instability of the ecosystem would cause variation in the diets and food composition. The model could be improved by introducing a suitability index which enhances the preferences of the species by taking the availability of their prey species into account (Pepin, 1987).

The biomass estimates obtained from trawl surveys were important to the model since the total catch from the region is not known. Though data obtained during cruises were corrected for selectivity and improper recruitment, the accuracy of absolute biomass estimates depending solely on trawl survey results is at best $\pm 50\%$ (Laevastu and Larkins, 1981). This is due mainly to the lack of information about the catchability of the trawl net used. The catchability of a fishing gear varies from species to species and also from one type of trawl rigging to another. In the model the catchability coefficient was always entered as 1, assuming all fishes encountered to be effectively captured and retained by the trawl net. This obviously underestimated the biomass of the stocks. If absolute estimates of the system are of crucial importance, there must be better prediction of the catchability coefficient, q . In its present form, the model utilizes the ratios of equally underestimated terms, and absolute values receive little emphasis.

The model assumes the north Mediterranean basin to be self-contained and one-dimensional. This is especially apparent in the discrepancies between the estimates of Z and P/B . According to Allen (1971), these two terms have essentially the same units and the instantaneous total mortality coefficient equals the ratio of total production to biomass (P/B). Total mortalities within the model compartments were estimated assuming the system to be a closed box, where all possible exchanges were ignored. This obviously neglects migration and other sources of losses. This may be the explanation for the contradiction between biomass and production estimates for *Spicara flexuosa* and *Boops boops* (Fig. 3). In the future, this problem will be redressed by incorporating a horizontal dimension into the model and by including biomass exchange between adjacent regions.

Finally, one cautions that the model utilizes only fishery and trophic relations within the trawl fishery system; other relationships due, for example, to pollution and climatic variability have been neglected. The ever-increasing pollution due to crude oil pumping plants has a considerable influence on the Gulf of Iskenderun which has been ignored in the context of this study. The combined long-term effects of all biologic and nonbiologic factors that have been ignored may obviously alter the steady-state assumption on which

the model was constructed. The findings of the present model should therefore be treated as a snapshot of the system during the defined periods. Since it is not a prognostic model, the utilization of the model for management purposes should, therefore, parallel a continuous supply of updated data.

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