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The Catch Composition and Catch per Unit of Swept Area (CPUE) of Penaeid Shrimps in the Bottom Trawls from İskenderun Bay, Turkey

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Abstract

The objectives of present study were (*i*) to identify catch composition, (*ii*) to determine the CPUE, and (*iii*) to determine the percentage of penaeid shrimps in the total economic catch. Surveys were conducted between March 2002 and February 2003 in İskenderun Bay (NE Mediterranean Sea). The sampling area was divided into two strata by depth and then the stratified random sampling technique was applied to collect data. During the study, *Penaeus semisulcatus* (de-Hann, 1844), *Marsupenaeus (Penaeus) japonicus* (Bate, 1888), *Merlicertus (Penaeus) kerathurus* (Forskal, 1775), *Metapenaeus stebbingi* (Nobii, 1904), and *Metapenaeus monoceros* (Fabricus, 1798) were observed in the catch composition. Among these species, *M. stebbingi* had the highest average catch rate (76.9%) among all total shrimp. A similar trend was observed in the total economic catch (5.1%). The mean catch per unit effort (CPUE ± SD) of the *M. stebbingi* (73.43±76.9 kg/km^2) was significantly higher than those of the other species. *M. stebbingi* was caught in both strata, while CPUE was the same in both stratum I and stratum II. However, the variability in stratum I was higher than in stratum II. Hyperstability or density-dependent catchability was not observed in either of the strata for any of the species (P > 0.05).

Key Words: Penaeid shrimp, Catch composition, Catch Per Unit Effort, İskenderun Bay

Introduction

Bottom-trawl fishing is very common in the Mediterranean Sea and has an important role from both an economic and a social standpoint (Sbrana *et al*., 2003). In this region, trawl catches are composed of a highly diversified mix of fish, cephalopods, and crustaceans, since the trawls that are used are not very selective (Colloca *et al*., 2003).

Crustaceans, such as clawed and spiny lobsters, crabs, and penaeid shrimp have recently become very important due to high demand for them in world markets. In Europe, approximately 22 crustacean species are fished commercially (Anonymous, 2003). The crustacean trawl fishery in İskenderun Bay is very significant due to its quantity and the economic value of its landings. Crustacean fishery, particularly of penaeid shrimp, has been carried out using a specially designed bottom trawl that is called shrimp-trawl in this region. However, the traditional trawl net has commonly been used to catch decapod crustaceans in İskenderun Bay.

Although some investigations have documented the biology and the fisheries of penaeid shrimps in Mediterranean countries (Bishara, 1976; Ishak *et al*., 1980; Abdel Razek, 1985; Bayhan, 1984; Kumlu *et al*., 1999; Can and Şereflişan, 2000), not enough research has been conducted on the catch composition and CPUE for this species in the Northeast Mediterranean Sea.

The objectives of this study are (i) to identify the catch composition (ii) to determine the CPUE and (iii) the percentage of this species in the total economic catch using bottom-trawl surveys in İskenderun Bay, which is located in North-East Mediterranean Sea.

Materials and Methods

The study was carried out between March 2002 and February 2003 in İskenderun Bay (Figure 1). A total of 40 bottom trawl hauls were performed using a net with a mesh size of 18 mm at the cod-end by using an R/V 'Mustafa Kemal-1'. Towing time varied from 60 to 170 minutes and speed was 2 knots/hour.

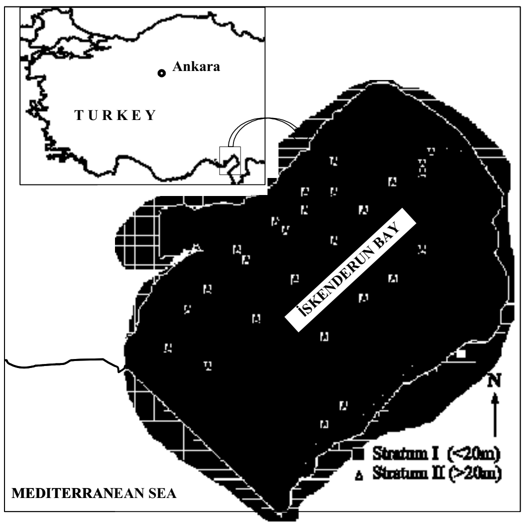

Figure1. Sampling area and trawled stations.

The sampling area was divided into two strata on the basis of depth (stratum I: 0-20 m and stratum II: > 20 m). The stratified random sampling technique was used to obtain samplings, and then the total areas of these two strata were calculated using a planimeter (Table 1). Deck sampling and catch record procedures were carried out as per Spare and Veneme (1992).

Catch per unit swept area (CPUE) is most often based on either commercial or survey data. Survey data are preferred because they are usually collected using a standardized procedure that is kept constant to the extent possible (Maunder, 2001). CPUE was calculated as being the catch weight (Cw) divided by the swept area (a) for each species and for each haul (Spare and Veneme 1992):

$$CPUE = Cw/a$$

The swept area (a) or the 'effective path swept' for each hauling was estimated thus:

$$a = D.h.X$$

where h is the length of the head-rope and D is the cover of distance. X is the fraction of the head-rope length which is equal to the width of the path swept by the trawl. The value of X varies from 0.4 to 0.66. It is suggested that X = 0.5 is the best compromise value for Mediterranean Sea (Spare and Veneme, 1992), but Bingel (2002) reports that this figure varies from 0.3 to 0.4 for Turkish deep trawl net. The value of X was taken to be 0.4 in this study. The distance covered (D_i) was estimated for each haul in units of nautical miles (Spare and Veneme, 1992), and subsequently converted to kilometres by multiplying by 1.852 (one nautical mile = 1.852 km):

$$D_i = 60x\sqrt{(Lat_1 - Lat_2)^2 + (Lon_1 + lon_2)^2 \cos 0.5^2 (Lat_1 + Lat_2)}$$

where Lat1: Latitude at the begining of the haul (degrees), Lat2: Latitude at the end of the haul (degrees); and Lon1: Longitude at the begining of the haul (degrees), Lon2: Longitude at the end of the haul (degrees). The coefficient of variation (CV) is used to assess variability. It is computed for every hauling and for the total hauling by stratum, where V is the variance:

$$CV = \frac{100.\sqrt{V}}{CPUE}$$

As the presence of zero catch for some hauls artificially increases the CV, such hauls were not considered in the data analysis (Somerton *et al.,* 2002).

To investigate hyperstability, we made the assumption that catch per unit effort (CPUE) would be proportional to biomass. Although a number of nonlinear models have been proposed, the simplest is the power curve (Maunder, 2001; Shelton *et al*., 2001), which uses the following formula:

$$CPUE = q(B)^{\beta}$$

where q is the catchability coefficient, B is the biomass by weight, and β is the shape parameter. If β <1, CPUE declines more slowly than B, resulting in hyperstability. Biomass estimations were calculated using the method of Spare and Veneme (1992).

Results

The mean catch per unit effort (CPUE) values for the various species and for both strata are given in Table 2. *Penaeus semisulcatus* (de-Hann, 1844) was observed in both strata, but with a higher CPUE in stratum II (12.57±13.99 kg/km^2) and a higher coefficient of variation (CV, 111.25%) in stratum II than in stratum I (0.81± 0.51 kg/km^2).

Metapenaeus stebbingi (Nobii, 1904) was also caught in both strata, with CPUE being about the same in both stratum I (76.38±103.24 kg/km^2), and stratum II (71.32±60.90 kg/km^2). However, the variability in stratum I (CV = 135.2%) was higher than in stratum II (CV = 85.45%).

Metapenaeus monoceros (Fabricus, 1798) was observed only in stratum II, with a CPUE of 47.84±5.76 kg/km^2.

Marsupenaeus (Penaeus) japonicus (Bate, 1888) was found in both strata. The CPUE for *M. japonicus* in stratum II (1.59±1.37 kg/km^2) was higher than in stratum I (0.44± 0.20 kg.km^{-2}), but the variability in

Table1. Number of Trawl Hauls (n), Area Swept (a) and Total Area (A) by Stratum

	Stratum I (0-20 m)	Stratum II (> 20 m)	Total
n	14	26	40
Total Area (A, km^2)	369.9	1133.6	1503.5
Swept area (a, km^2)	1.18	2.68	3.86

Table 2. Mean CPUE (± SD) and Coefficient of Variation (CV) for Strata and Total Area Among the Species

Species	Stratum I	CV(%)	Stratum II	CV(%)	Total Area	CV(%)
P. semisulcatus	0.81±0.51	63.1	12.57±13.9	111.25	9.96±13.29	132.80
M. stebbingi	76.38±103.24	135.2	71.32±60.9	85.45	73.43±76.9	104.67
M. monoceros	-----	-----	47.84±5.76	118.98	47.84±5.80	118.98
M. japonicus	0.44±0.20	45.74	1.59±1.37	86.44	1.01±1.10	108.78
M. kerathurus	0.47±0.09	19.32	1.55±1.43	92.33	1.25±1.30	103.58

the stratum II (CV = 86.64%) was higher than in stratum I (CV = 45.74%).

Melicertus (Penaeus) kerathurus (Forskal, 1775) was observed in both strata. The CPUE in stratum II (1.55±1.67 kg/km^2, CV = 92.33%) was higher than in stratum I (0.47±0.09 kg/km^2, CV = 19.32%).

In total area, *Metapenaeus stebbingi* had the highest CPUE (73.43±76.90 kg/km^2), followed by *Metapenaeus monoceros* (47.84±5.76 kg/km^2), *Penaeus semisulcatus* (9.96±13.29 kg/km^2), *Melicertus kerathurus* (1.25±1.30 kg/km^2), and lastly *Marsupenaeus japonicus* (1.01±1.10 kg/km^2).

Among the species caught, *Metapenaeus stebbingi* showed the highest catch rate (5.10%) in the total economic catch (Table 3). The same pattern was observed in the total shrimp catch: *M. stebbingi* constituted 76.9% of the total shrimp catch, far ahead of the other species: *P. semisulcatus* (18.20%), *M. monoceros* (2.30%), *M. kerathurus* (1.50%), and *M. japonicus* (1.20%).

The β parameter in the CPUE-biomass relationships was established at 1.00–1.11 and 1.00–1.54 for stratum I and stratum II, respectively. However, hyperstability or density-dependent catchability was not detected for any of the species in either of the strata (P > 0.05) (Table 4).

Discussion

Since 1965, a total of 193 decapod species have been identified in Turkish seas (Kocataş and Katağan, 2003). Yet only seven of these species belong to the family Penaeidae, which is commercially important for fisheries in the eastern Mediterranean Sea (Kocataş *et al*., 1991). These species are *Penaeus semisulcatus*, *Marsupenaeus japonicus*, *Penaeus kerathurus*, *Parapenaeus longirostris* (Lucas, 1846), *Metapenaeus monoceros*, *Metapenaeus stebbingi*, and *Trachypenaeus curvirostris* (Stimpson, 1860). Kumlu *et al*. (1999) identified three penaeid shrimp species in İskenderun Bay as follows: *P. semisulcatus*, *M. monoceros*, and *M. stebbingi*. In recent years, *Melicertus hathor* (Burkenroad, 1959) has also been reported by Kumlu *et al*. (2002). In addition, *Parapenaeus longirostris*, *P. semisulcatus*, and *M. monoceros* have been reported to occur in the same area (JICA, 1993). All of these species have been fished using commercial fishing vessels (Kumlu, 2001). In Kuwait's fisheries, four of the 13 species of shrimp occurring there are commercially important: *P. semisulcatus*, *Metapenaus affinis* (H. Milne – Edwards, 1837), *Parapenaeopsis styliferia* (H. Milne – Edwards, 1837) and *M. stebbingi* (Abdul-Ghaffar, 1995), and of these, *P. semisulcatus* accounts for more than 90% of all shrimp landings there (Kedidi, 1995). Within the Suez Canal, *M. stebbingi* makes up >90% of the total prawn catch (Ghobashy *et al*., 1991).

In our study, we observed *P. semisulcatus*, *M. japonicus*, *M. kerathurus*, and *M. stebbingi* in both strata. However, *M. monoceros* was only caught in strata II. It is possible to accept this result as being

Table 3. The percentage of Penaeid shrimp in total economic and shrimp catch by species and strata

Species	Total Shrimp Catch (%)		Total Economic Catch (%)		Total Area	
	Stratum I	Stratum II	Stratum I	Stratum II	Total Shrimp Catch (%)	Total Economic Catch (%)
P. semisulcatus	1.23	25.03	0.16	1.97	18.20	1.20
M. stebbingi	97.44	68.48	16.09	5.41	76.90	5.10
M. monoceros	-----	3.24	-----	0.25	2.30	0.15
M. japonicus	0.80	1.29	0.13	0.10	1.20	0.07
M. kerathurus	0.51	0.15	0.13	1.92	1.50	0.10

Table 4. Hyperstability or density-dependent catchability control for all species in both strata

Species	Stratum I (CPUE=aB^{β})		Stratum II (CPUE=aB^{β})	
P. semisulcatus	β = 1.11, R^2= 0.86	P>0.05	β = 1.14, R^2= 0.91	P>0.05
M. stebbingi	β = 1.02, R^2= 0.99	P>0.05	β = 1.00, R^2= 0.98	P>0.05
M. monoceros	-----		β = 1.54, R^2 = 0.73	P>0.05
M. japonicus	β = 1.01, R^2 = 0.78	P>0.05	β = 0.92, R^2 = 0.98	P>0.05
M. kerathurus	β = 1.00, R^2= 0.94	P>0.05	β = 1.01, R^2= 0.64	P>0.05

valid because adult *M. monoceros* specimens have inevitably been found in deeper waters only (Baily-Brock and Moss, 1992).

Among the species, *M. stebbingi* had the highest catch rate (76.85%). This species can live in different environmental conditions, such as brackish and salt waters. Although interaction with the environment was not identified or quantified, this characteristic may play a role in the species abundance and distribution.

JICA (1993) used the trawl net and the shrimp-trawl net both at night and during the day for surveys in İskenderun Bay. It was indicated that the CPUE during the day was three times as high as that of the night surveys, in all strata. In those surveys, the CPUE of *P. semisulcatus* was determined to be 567 g/km^2 in daytime. This value is much smaller than the value found in the present study (9.96 kg/km^2). Additionally, the CPUE of *M. japonicus* yielded such a low value that it was not expressed in terms of weight but instead was presented as 10 $specimens/km^2$, whereas in the present study, the CPUE of *M. japonicus* was 1.01 kg/km^2. JICA (1993) and the present study were conducted in same area, using bottom trawl, but the results were quite different. Possible reasons for the occurrence of such differences are given below:

(a) Tow duration: In the present study, the duration of the tows varied from 60 to 170 minutes, whereas in the JICA survey it was held constant at 30 min.

(b) Survey season: We conducted our surveys over nearly one whole year, i.e., in various seasons, but JICA conducted their surveys only in autumn.

(c) Haul number: In the present study, the number of hauls considered (n = 40) was much higher than in the JICA surveys (n = 7).

In general, the degree of variation in CPUE in stratum II was higher than they were in stratum I. This may be a result of the differential patterns of migration for the shrimp inhabiting shallower waters as opposed to those inhabiting deeper waters.

A number of studies show that the area occupied by a fish stock is positively correlated with stock abundance. If fishing vessels are able to locate fish concentrations independently of population size, catchability may in fact increase with decreasing population size. This principle, referred sometimes as hyperstability or density-dependent catchability, may lead to overestimation of biomass and underestimation of fishing mortality (Shelton *et al*., 2001; Salthaug and Aanes, 2003). In the present study, hyperstability was not detected. Thus, the catch per unit effort in both strata by species can be considered to be an indication of stock abundance.

Smith and Addison (2003) report that crustacean fisheries are becoming increasingly important and now account for 7% of all fish and shellfish landings by weight and 28% by economic value. In this study, we found that these five species contributed nearly 7% of the total economic catch in İskenderun Bay. In order to achieve sustainable exploitation of this marine resource, these stocks should be regularly monitored, and the migration pattern, the predator-prey relationships, growth and mortality parameters should be determined to gain sufficient knowledge to manage these stocks effectively. Thus, it is necessary to study these factors for planning an effective management strategy that can be recommended to the government.

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