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Turbot (*Psetta maxima* L.) Abundance Indices and Stock Dynamics of Bulgarian Black Sea Coast During the Period 2006-2009

Marina D. Panayotova*, *Violin S. Raykov*, *Valentina R. Todorova

Institute of Oceanology – Bulgarian Academy of Sciences, 9000 Varna, 40 Parvi may Str., POB152; E-mails: mpanayotova@io-bas.bg; vraykov@io-bas.bg; vtodorova@io-bas.bg

Abstract: The dynamics of indices of turbot abundance and biomass in front of Bulgarian Black Sea coast were studied using the swept area method during the period 2006-2009. Catch – per – unit – effort and catch – per – unit area data from 260 bottom hauls were collected during 7 trawl surveys in the period 2006-2009. The estimated turbot relative biomass ranged between 447.4 and 1966.2 t, at the average of 1520 t. The average catch – per – unit – effort and catch – per – unit area ranged between 1.97 and 13.94 $kg.h^{-1}$ and 94.88-397.88 $kg.km^{-2}$ respectively. According to survey estimates, the turbot stock was concentrated predominately at depths 50-75 m. The higher levels of the turbot biomass indices were established by the end of 2008. In 2009 a reduction in the biomass and abundance indices was observed. If the decline persists during the next years, measures to protect the turbot stock will be necessary.

Key words: turbot, abundance, biomass, catch – per – unit – effort, catch – per – unit – area, Black Sea

Introduction

Turbot (*Psetta maxima*) occurs over the whole Black Sea continental shelf grouped in local shoals reaching depths of 100-120 m in the north – western area. The species inhabits sedimentary bottoms – sands and silty sands, mussel beds, as well as mixed seabed of sand and boulders. The turbot has a life span of 10-12 years in Bulgarian area (Karapetkova, Zivkov 2006) and reaches up to 87 cm in length and up to 15 kg in weight (Karapetkova, Zivkov 2006). *P. maxima* is not a highly migratory species but relocates seasonally towards the coast and offshore related to reproduction, feeding and wintering. It also tends to migrate to the north along the Bulgarian coast in order to compensate against southward drift of eggs and larva by currents (Stoyanov, Ivanov 1966, Karapetkova, Zivkov 2006). In all Black Sea countries turbot is highly priced due to high market demand and consequently an important target species for the commercial fisheries. In Bulgaria it is caught by specialised bottom – set gill nets, as well as illegally by bottom trawls. Turbot is also by – catch of sprat fisheries and beam trawls targeting on rapa whelk (*Rapana venosa*).

Previous studies on turbot stocks of the Bulgarian coast cover biology, distribution and population dynamics of the species (Martino and Karapetkova 1957, Karapetkova 1961, Stoyanov *et al*. 1963, Nikolov 1967, Ivanov and Beverton 1985, Ivanov and Karapetkova 1979, Prodanov *et al*. 1997, Prodanov and Mikhailov 2003, Panayotova *et al.* 2006, 2007a, 2007b, 2008a, 2008b, 2008c, 2009, 2010) its stock assessment and sustainable ex-

ploitation (Ivanov and Beverton 1985, Prodanov *et al*. 1997, Panayotova and Todorova 2008, Raykov *et al.* 2008).

The aim of this study is to evaluate the current trends in abundance indices of turbot in Bulgarian Black Sea during the period 2006-2009 and gather new information on the turbot population.

Study Area

Seven successive surveys were carried out in front of Bulgarian Black Sea coast during the spring and autumn – winter seasons in the period 2006-2009 including altogether 260 hauls. The research area was divided into four strata according to depth: Stratum 1 (35-50 m), Stratum 2 (50-75 m), Stratum 3 (75-100 m) and Stratum 4 (15-35 m) – Fig. 1. Each stratum was partitioned into equal in size, not overlying rectangular fields with sides 5' Lat × 5' Long and area around 62.58 km^2, large enough for a standard haul to fit within the field boundaries in meridian direction. During each survey 24 to 47 randomly chosen fields were sampled by means of bottom trawls.

Material and Methods

A standard methodology for stratified random sampling was employed (Gulland 1966, Sparre and Venema 1998, Sabatella and Franquesa 2004). The method is based on bottom trawling across the seafloor (area swept) and is widely used as a direct method for demersal fish stock assessment when only an index of abundance is required (Sparre and Venema 1998, Medits 2007, 2010). The seabed area covered during a single haul represents a basic measurement unit, which although very small compared to the total study area is deemed representative since turbots do not aggregate in dense assemblages (Martino and Karapetkova 1957). The fields are grouped in larger sectors – so called strata, with geographic and depth boundaries selected according to the density distribution of the species under study (Martino and Karapetkova 1957, Panayotova *et al.* 2006, 2007a, 2007b, 2008a, 2008b, 2008c, 2009).

Identical fishing vessel and gear were used in all surveys except from the first (pilot) study in 2006 when two different types of vessels were employed. The usage of the same vessel and trawling gear ensured consistency of methodology (fishing effort) and reduces variations between years due to vessel effect. Small fishing vessel 'Elis' (15.6 m length, engine power 177 HP, tonnage – 20 t, crew – 4 people) was selected due to lack of research vessel, having at disposal the required gear. The advantages of fishing vessel were the low cost and the high efficiency compared to the research vessel. Disadvantages included working period restriction due to vessel instability in case of rough sea, space limitation on board and impossibility for monitoring of environmental parameters.

The dimensions of the bottom trawl employed were as follows: head rope length – 26 m; mesh size – 10x10 cm and effective part of wing spread – 10-12 m. Lugs were carried out only during daylight with haul duration of 90 min – 180 min at trawl speed 3.334 km.h^{-1} on the ground.

Swept area method

The swept area method was used for estimation of turbot relative abundance and biomass indices. The swept area, a, can be estimated from equation 1:

(1) a = D*hr*X2

D = V*t,

where: a – swept area, V – velocity of the trawl over the ground, X2 – fraction of the head – rope length hr, which is equal to the width of the path swept by the trawl, the 'wing spread', t – is the time spent trawling , D – distance covered.

For the estimation of turbot relative biomass, the catch per unit of area (CPUA) was used – equation 2:

(2) $\frac{C_{w/t}}{a/t} = \frac{Cw}{a} kg.km^{-2}$,

where: Cw/t – catch in weight per unit of area, a/t – the area swept per hour.

The relative biomass of the investigated species for each stratum was obtained from equation 3:

(3) $B = \left(\overline{C_{w/a}}\right) * A$,

where: $\overline{C_{w/a}}$ – the mean catch per unit area of all hauls, A – the total size of the area under investigation in stratum.

The mean catch for the entire survey area was obtained from equation 4:

$$\overline{Ca}(A) = \frac{Ca1 * A1 + Ca2 * A2 + Ca3 * A3 + Ca * A4}{A},$$

where: Ca1 – catch per unit area of stratum 1, etc., A1 – area of stratum 1, etc., A – total area of survey region.

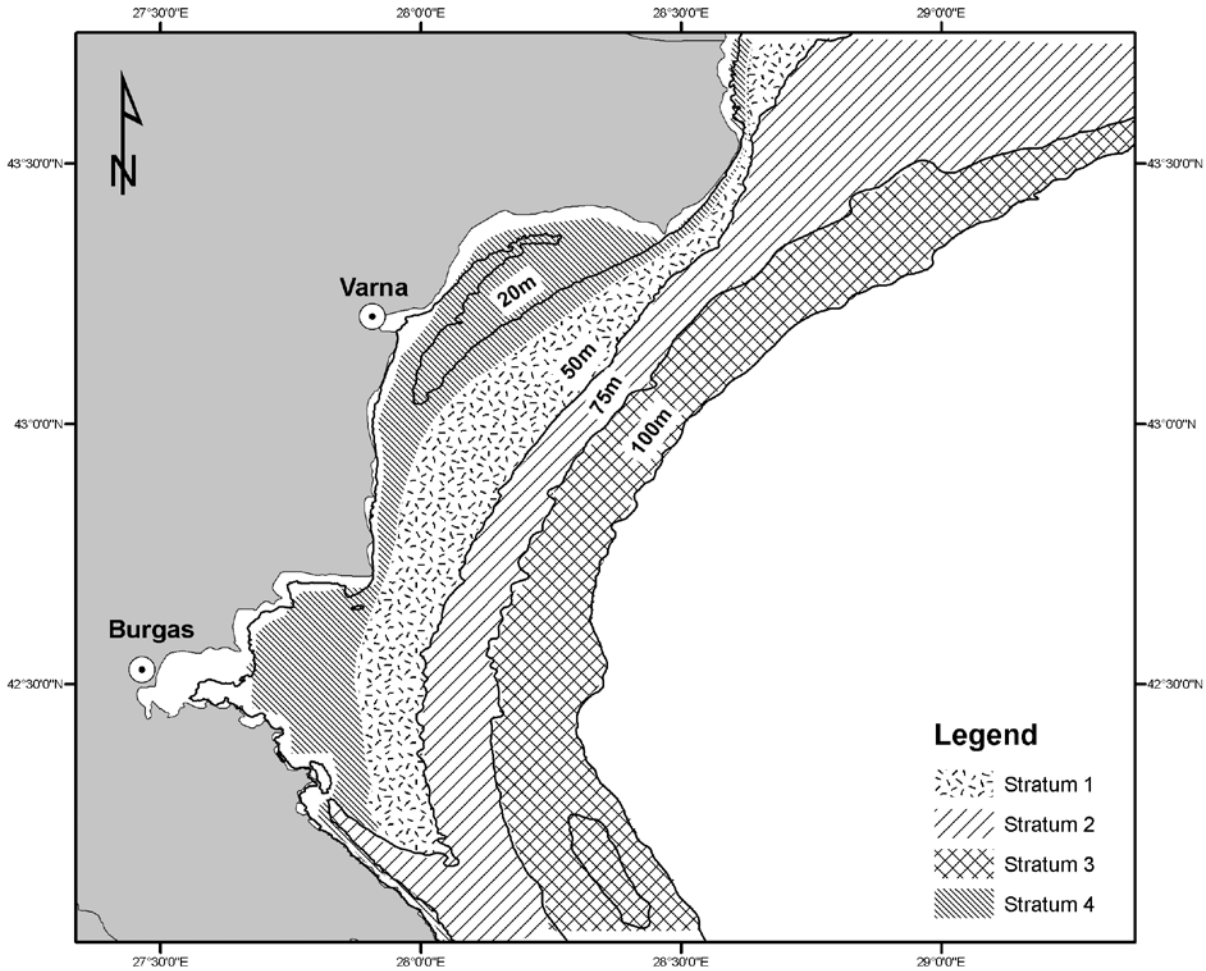

Fig. 1. Map of study area.

The relative biomass in the survey area was estimated by equation (5):

$$(5) \quad B = \frac{\overline{Ca}(A)}{X1} * A \ ,$$

where: $\overline{Ca}(A)$ – mean catch for the entire survey area, A – total area of survey region, X1 – catchability.

Precise estimate of X1 is difficult to be given due to unknown proportion of the fish that is present in the area swept by the trawl gear and those which actually retained by the gear. The value of X1 is usually chosen between 0.5 and 1.0 (Sparre and Venema 1998). In this case, the X1=1 was applied.

$$(6) \quad CPUE = \frac{Cw}{t},$$

where: Cw – catch in weight of a haul, t – the time spent hauling (in hours).

The swept area method is usually applied for the estimation of relative biomass and abundance indices due to following pros and cons, according to Foote (1996):

Pros: sampling procedure is under control; the reliability of the data obtained; the data are independent from commercial fisheries.

Cons: representative character of the sampling; the trawl is selective and does not fully present exploited stock; sampling is possible on the soft bottom only; uncertainty in trawl catchability.

Results and Discussion

Biomass

The first assessment of turbot biomass in front of Bulgarian coast was carried out by Martino and Karapetkova 1957 using a non – stratified swept area survey and the stock was assessed at around

850 t. Later Kolarov and Karapetkova 1993 reported that the turbot biomass was reduced to 100 t and a 4 – year moratorium for fishing was established. The recent assessments by the more precise stratified swept area method started in 2006 (Panayotova *et al*. 2006, Panayotova *et al*. 2007a, Panayotova and Todorova 2008, Raykov *et al.* 2008). During the period 2006-2009, the estimated relative biomass indices of turbot varied between 447.4 and 1966.2 t (Table 1) and distribution by strata is presented on Fig. 2.

Table 1. Estimated relative biomass of turbot in front of Bulgarian Black Sea coast during the period 2006-2009.

Survey	**Biomass (t)**
Spring, 2006	447.38
Autumn – winter, 2006	1441.10
Spring, 2007	1778.76
Autumn – winter, 2007	1896.57
Spring, 2008	1966.18
Spring, 2009	1502.04
Autumn – winter, 2009	1609.84
Mean 2006 – 2009	1520.27
SE	193.52
CI (95%)	1046.73 – 1993.80

The observed confidence interval of estimated biomass values ranged between 1046.73 – 1993.80 t (Table 1). The biomass index in spring, 2006 was underestimated due to employment of two different fishing vessels and gears. In the next surveys that uncertainty was overcome.

The obtained results show close values of turbot biomass indices in front of Bulgarian Black Sea coast with some variations between seasons and years. Higher biomass values were observed in autumn – winter seasons of 2006, 2007 and 2009. For 2008, data were not available because demersal survey was not carried out.

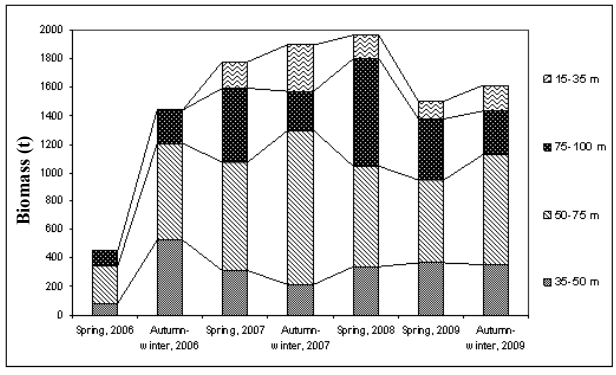

Fig 2. Distribution of turbot relative biomass by strata during the demersal surveys in the period 2006-2009.

The major share of turbot biomass and maximum values were observed in the stratum 50-75 m in all surveys both in spring and autumn – winter seasons (Fig. 2), except the results in spring 2008, when the maxima was shifted to the deeper water (75-100 m). Fig. 3 shows the average relative biomass by strata with corresponding upper and lower 95% confidence intervals during the period 2006-2009.

The figure reveals a maximum of turbot biomass indices at depths between 50-75 m (Stratum 2). Very close values were observed at depths 35-50 m (Stratum 1) and 75-00 m (Stratum 3). The depths between 50 and 75 m are commonly inhabited by the most abundant fish populations such as whiting, sprat, gobies, etc., which compose a major share of turbot diet and the availability of food resources provide favorable conditions for high turbot concentration (Bulgurkov 1965, Karapetkova 1962). The depths between 50-75 m are also the main fishing grounds and the majority of turbot gillnets during the spring season are concentrated in these strata. The shallow areas between 35-50 m were dominated by juveniles and immature individuals and their biomass index attained relatively high levels –314.76 t on the average. This fact indicated abundant turbot recruitment over the period 2006-2009 that possibly would increase the stock biomass during the next years if there is no substantial overfishing.

Catch per unit effort

Catch – per – unit – of – effort (CPUE) is often used in fisheries stock assessments and is usually assumed to be proportional to the abundance of fish at sea. Catch per unit effort of turbot surveys during the period 2006-2009 was investigated. Observed average values of CPUE during the period 2006-2009 are similar within seasons as evident from Fig. 4 with mean values of 8.14 kg.h^{-1} and 9.73 kg.h^{-1} in spring and autumn – winter seasons respectively. In all years CPUE attained higher values in autumn due to intense feeding and growth after spawning in April – June. The average CPUE values in autumn – winter season ranged between 8.93 and 10.22 kg.h^{-1} and during the spring season – between 7.56 and 9.32 kg.h^{-1}. In 2009 lower CPUE rates in both seasons were observed.

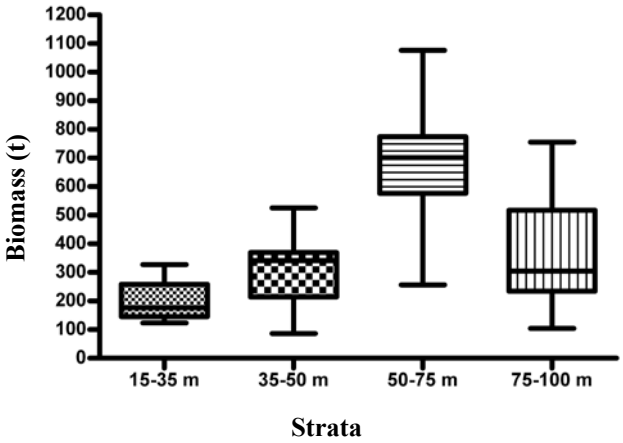

Fig. 3. Average turbot relative biomass (t) and CI (95%) by strata in Bulgarian Black Sea area during the period 2006-2009.

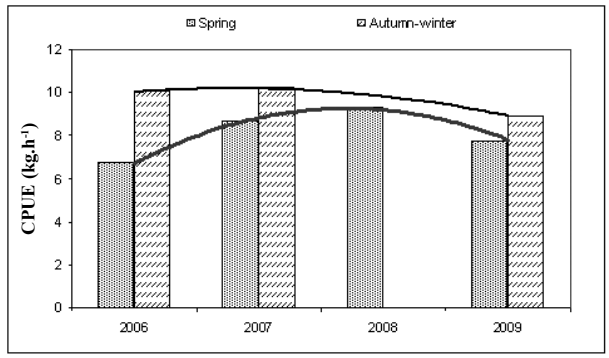

Fig. 4. Average values of survey CPUE by seasons and years in Bulgarian Black Sea area during the period 2006-2009.

The lowest observed value of CPUE (6.75 kg.h $^{-1}$) in 2006 was due to different vessels and gears employment during the survey. It is evident from the results, that turbot catches per hour during the period 2006 – 2009 are relatively stable – 8.82±1.14. kg.h $^{-1}$.

Standardization of the observed average CPUE values by strata shows alterations during different studies. In Stratum 1 reduction in CPUE was observed after the end of 2006. On the contrary, in Strata 2 and 4, higher values was observed after spring of 2007 and in Stratum 3 – after the end of 2007. The highest average CPUE values by strata were observed in Stratum 2 (10.10 kg.h $^{-1}$), which covers depth between 50-75 m, followed by Stratum 4 (15-35 m) – 8.53 kg.h $^{-1}$, Stratum 1 (35-50 m) – 7.11 kg.h $^{-1}$ and Stratum 3 (75-200m) – 7.03 kg.h $^{-1}$.

In 2009, reduction in estimated relative biomass index and CPUE values in both seasons was registered. One of the reasons probably is illegal and unreported fishing on turbot, which increased after 2007, when the turbot export was permitted. The species is high priced on neighbor's countries fish markets, which provokes increase in the illegal catches. During the all surveys, we found unmarked by the NAFA authorities 'ghost' poacher nets, some of them old, which continue to work and to catch fish and marine mammals.

Catch per unit area

Catch – per – unit – area (CPUA) from demersal surveys is an indicator for turbot abundance, which together with Catch – per – unit – effort are useful tool for studying tendencies in fish stock dynamics and spatial distribution. The distribution of the average CPUA values and correspondingly of turbot stock by strata during the period 2006-2009 is presented on Fig. 5. High levels of CPUA and correspondingly high densities of turbot during the period 2006-2009 were observed in Stratum 2 (50-75 m), followed by Stratum 4 (15-35 m) with mean values of 260.732 kg. km $^{-2}$ and 243.01 kg.km $^{-2}$, respectively.

Standardized values of Catch – per – unit – area indices per strata show different tendencies of distribution of turbot catches per square kilometre during the seasons and years in the period 2006 – 2009 (Fig. 6). In Stratum 4 and Stratum 2, the CPUA values increased until the end of 2007 (both seasons) and after that the CPUA decreased. In Stratum 3, CPUA gradually increased till 2008 (spring seasons) and dropped at low levels in 2009. High levels of CPUA in Stratum 1 at the beginning of the period decreased in the end of 2007 and started to increase during the next years.

According to the obtained results from all surveys, turbot stock is distributed over the whole Bulgarian shelf area down to 100 m depth with high aggregations between 50 and 75 m, where abundant food resources and favourable habitats exist. Assessment on turbot stock by swept area method in 2006-2009 were carried out in Romanian waters as well (Maximov *et al.* 2009, Maximov *et al.* 2010a, Maximov *et al.* 2010b) with the same trend of reduction after 2008. The rest of Black Sea countries (Turkey, Georgia, Russian Federation and Ukraine) did not fulfil turbot surveys. The last survey carried out by Ukraine was in 2007. In this view, the tendency could not be compared within the described period.

In Bulgaria, the turbot stock is targeted by the fisheries over the whole area of distribution, both in

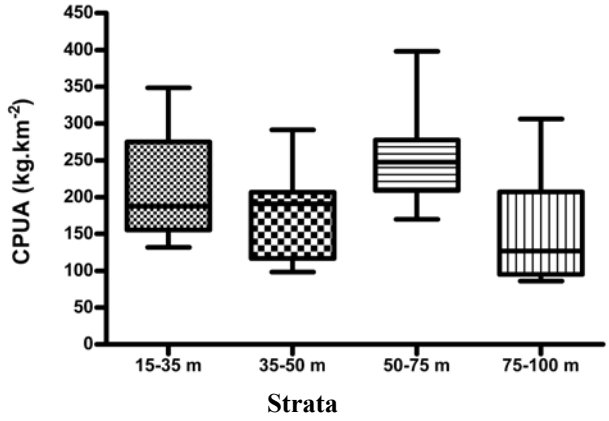

Fig. 5. Average values of CPUA from demersal surveys and CI (95%) by strata in Bulgarian Black Sea area during the period 2006-2009.

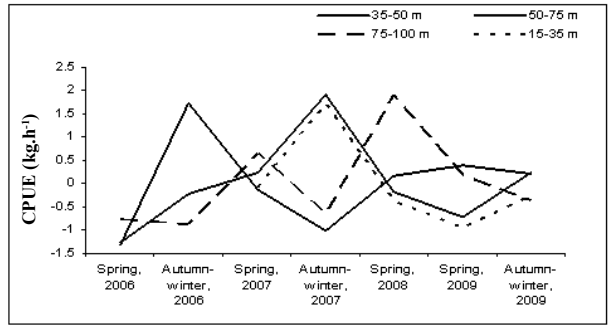

Fig. 6. Trends in standardised values of turbot survey CPUA by strata and surveys in Bulgarian Black Sea area during the period 2006-2009.

shallow and deeper areas, which practically causes reductions in both spawning stock and recruitment. The species is very sensitive to high fishing pressure due to long life span and relatively late reproduction onset (at the age of 4-5 years). For that reason, the TACs for turbot landings in 2007-2009 and quotas allocations were introduced (Council Regulations (EC) No 1579/2007, No 1139/2008, No 345/2009) for Bulgaria and Romania. For the rest of Black Sea countries, legal basis for the management is in accordance with their national legislations. Additional technical measures as minimum legal mesh size and prohibition during reproduction period are in force in Bulgaria and Romania. In 2008, joint stock assessment group was established under STECF (EC) that had started to fulfil contemporary stock assessments on turbot and other commercially important species (Pilling *et al.* 2008, Daskalov *et al.* 2010). Recent trends in turbot stock show low rates of stock spawning biomass and recruitment and higher fishing pressure due to illegal fishing at regional level since 2000 (Daskalov *et al.* 2010). For protection and sustainable use of turbot stock at national and regional scale, the implementation of effective management measures limiting the fishing pressure are critically needed as well as improved data quality for stock assessment purposes.

Conclusions

Recent surveys assessing turbot stock along Bulgarian Black Sea coast show relative biomass levels ranging between 447.38 t and 1966.2 t, at the average 1520 t. The major share of turbot biomass and maximum values of catch – per – unit – effort and catch – per unit – area were observed at depths between 50-75 m, where the main fishing grounds are located. In 2009 reductions in biomass, CPUE and CPUA were observed probably related to the intensive fishing in the area, both officially reported, unreported and illegal, that likely exceeded official landings and prevents assessment of the real fishing pressure. Measures for protection of turbot stock are necessary if the decreasing trend continues during the next years.

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