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The State-of-Art of the Black Sea Turbot Spawning Population off Crimea (1998-2010)

Vitaly Giragosov[1], Antonina Khanaychenko[1,*]

[1] Institute of Biology of Southern Seas, 2 Nakhimov av., 99011, Sevastopol, Ukraine.

* Corresponding Author: Tel.: +380.692 550990; Fax: +380.692 557813;
E-mail: a.khanaychenko@gmail.com

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Abstract

Long-term study (1998–2010) of the Black Sea turbot spawning population in Sevastopol region (Crimean coast, Ukrainian sector of the Black Sea) was carried out on the basis of monitoring of the turbot gill net catches. Despite some signs of recovery of BST local population during 2009-2010, analysis revealed numerous signs of absence of stability in the local turbot population: low sizes of spawners in comparison with other Black Sea areas, permanent inverse sex ratio, high level of pigmentation abnormalities coming from early development and high level of diseased adult individuals which reflect fishery effects and unfavorable environmental conditions

Keywords: Black Sea turbot, Crimea, spawning population, structure, pigmentation, disease.

Introduction

The Black Sea turbot (or kalkan)-one of the most valuable commercial species in all countries of the Black Sea basin, and in Ukraine, in particular. Considered as a transboundary stock and, therefore, shared resources it is supposed to be regulated cooperatively by all Black Sea countries (Daskalov and Ratz, 2011). Exploited population is fished till now in some areas not only by gillnets but also by bottom trawls despite general opinion that this is a very aggressive and disruptive fishery method.

Taxonomic name (and even position) of the Black Sea turbot is rather confusing story being changed through more than 100 years history of its scientific investigation, with numerous names used concurrently by different groups of researchers. FishBase (www.fishbase.us/summary/Scophthalmus-maeoticus.html) still recommends using the name *Scophthalmus maeoticus* (Pallas) for the Black Sea turbot (along with synonym *Psetta maxima maeotica*). Additional genetic study is needed to specify its position (possibly, on the subspecies level). Currently, the microsatellite analysis of the Black Sea turbot is carried out by joint research of ILVO (Belgium) and IBSS NASU (Ukraine) to clarify its genetic status. To avoid confusions in taxonomy, further in this paper we use the abbreviation of the Black Sea Turbot (BST).

Besides, its importance for fisheries BST could be considered the key species for monitoring and analysis of on-going processes in the Black Sea environment. This species (at different stages of its development) is distributed all over the Black Sea continental shelf from 1 m depths to about 100 -110 m grouped in local shoals. Through its life-span BST cover practically all habitats of the Black Sea: pelagic eggs being lifted after fertilization from 50-100 m depths become neuston component till hatching (Gordina, 1999); pelagic larvae during 4 weeks minimum are part of the plankton community; metamorphosing larvae move to the coastal waters; metamorphosed settled BST fry could be found at their nursery grounds in coastal benthic communities up to 5-10 m depths; juveniles move to deeper waters (10-20 m) migrating to feeding grounds; and sexually matured part of population 4-5 years old inhabit various depths, up to 110 m, and appear at spawning grounds at 50-90 m (Marti, 1939).

Turbot in the Black Sea is represented by several local populations that could be considered independent units of the stock (Daskalov and Ratz, 2011), and the knowledge of state-of-art of local BST populations is needed for accurate assessment of general BST stock.

The aim of our study was to assess the up-to-date status of BST in the area of the South-Western Crimean shelf (Sevastopol region, Ukrainian sector)

on the base of monitoring of different characteristics of the local wild stock during its natural spawning period and to reveal features of BST morphological malformations obtained at different stages of its life cycle.

Materials and Methods

Current study was carried out in Sevastopol region (SW off Crimea, Black Sea). Fish for analysis were obtained from scientific catches of IBSS NASU and landings of local artisanal fishery companies in the coastal waters off Sevastopol by the gill nets (180-200 mm) at the depths 25–95 m (99% of catches from the depths over 50 m) during the BST spawning periods April-June 1998–2010. Integrated biological and morphological analysis of 2645 BST specimens caught during 1998–2010 was carried out; total (TL) and standard length (SL), weight (W_{total}) and gender were recorded. The age was determined by otoliths and age-length keys.

From 2007 onwards systematic monitoring of population structure, morphological and pigmentation patterns and visually detected diseases in BST local population was started according to our own developed technique and scheme. Digital images of both sides of all fish were acquired and malpigmentation, malformations and externally visible diseases were assessed as share (%) from gender and total number of analyzed stock. Only true malpigmentation (primary abnormal pigmentation obtained during metamorphosis and irreversible onwards) was taken in consideration during analysis; pigmentation disturbances were categorized in 6 grades of hypermelanization degree and area on the right (blind) side of the body. Preliminary results on abnormalities in BST pigmentation was carried out in 2005-2007 and assessed at 6 grades level (from spotted pigmentation in the tail area – 1 grade – to totally pigmented blind side of the body – true ambicoloration-6 grade) (Khanaychenko *et al.*, 2008). Migration patterns of the right eye and different skeleton abnormalities were also registered.

Results

The BST adult spawning specimens caught by gill nets during the spawning seasons 1998-2010 were characterized by total length (TL) ranging within 32.7–84.0 cm (mean ± c.i. = 51.6±0.24 cm), standard length (SL) was 26.0–71.0 cm (41.7±0.20 cm), total weight (W_{total}) 0.5–12.5 kg (mean 2.64±0.05 kg) (Figure 1), age 3-16 years (6.6±0.06 years).

Length frequency for both genders (pooled data 1998-2010) show that modal TL class (50.1-55.0 cm) accounted for 33.2% of total number of specimens, modal SL class (40.1-45.0 cm) 38.6%, modal weight class (2-3 kg) 43.6%, modal age class (6 years) 34.7%. Female modal TL class was 55.1-60.0 cm (29.3% of total number of females), modal SL class was 45.1-50.0 cm (34.4%) and modal weight class – 3-4 kg (27.2%). Significantly lower male modal TL class 45.0-50.1 cm accounted for 37.6% of total number of males, modal SL class 40.1-45.0 cm for 41.2% and modal weight class 2-3 kg for 49.1%. The length frequency by gender (pooled data 1998-2010) shows that the smallest specimens with TL within 32.7-41.3 cm (SL within 26.0-33.4 cm) were presented only by males, while the largest size group TL within 68.1-84 cm (SL 59.6-71.0 cm) only by females.

During the last scientific monitoring in 2010 spawning season, the BST specimens were characterized by TL ranging within 41.3-74.5 cm

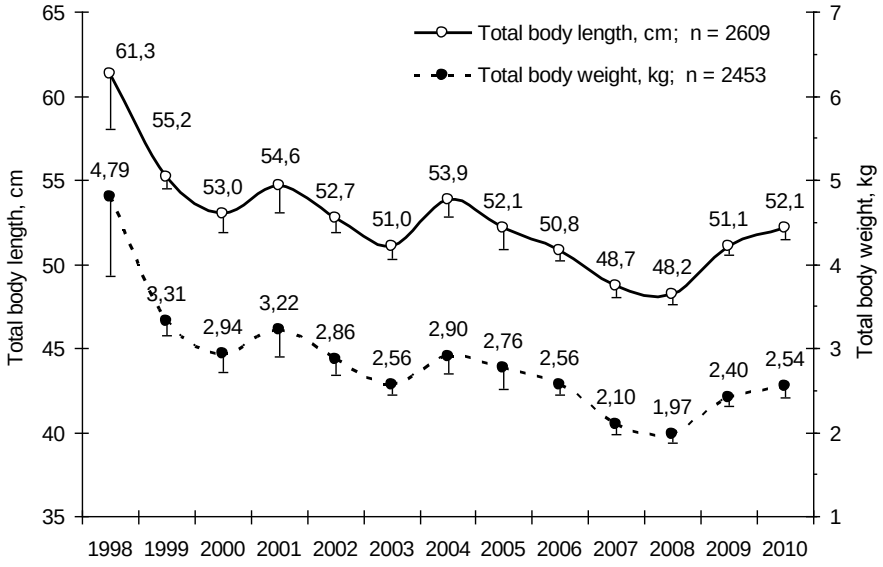

Figure 1. The Black Sea turbot body total length and weight - mean ± confidence interval - from gill nets at the 50-95 m depths in Sevastopol region in April – mid-June 1998-2010.

(52.1±0.71 cm), SL was 34.2-60.3 cm (42.2±0.59 cm), W_{total} 1.08-7.58 kg (2.54±0.14 kg) and age 4-10 years (6.3±0.15 years). Length frequency for both genders shows that modal TL class (50.1-55.0 cm) accounted for 44.6% of total number of specimens, modal SL class (40.1-45.0 cm) 49.7%, modal W_{total} class (2-3 kg) 53.7%., modal age class (6 year) 41.1%.

Females modal TL class was 55.1-60.0 cm (46.7% of total number), modal SL class 45.1-50.0 cm (50.0% of total number) and modal W_{total} class 3-4 kg (36.7%). Significantly lower modal TL class of males was 45.0-50.1 cm (37.2%), modal SL class – 40.1-45.0 cm (53.8%) and modal W_{total} class – 2-3 kg (60.7%). The length frequency by gender shows that the smallest specimens with TL within 41.3-46.9 cm (SL within 34.2-37.3 cm) were presented only by males, while the largest size group TL 62.1-74.5 cm (SL 50.4-60.3 cm) only by females.

Genders ratio through 1999-2010 was unequal, with males prevailing permanently in BST spawning wild stock (Figure 2). Male : female ratio make up on average 4.79 : 1 (82.7% : 17.3%) with a peak in 2002 – 13.3 : 1 (93% : 7%). In 2010 this ratio accounted for 4.83:1 (82.9% : 17.1%).

BST specimens during monitoring of all BST catches in Sevastopol region presented only different grades of hypermelanization on the blind (right) side of the body. Never were recorded hypomelanized specimens (ocular side malpigmentation), opposed to NW Black Sea-Odessa coastal area-where practically totally hypomelanized on the left (ocular) side BST were recorded in 2003-2005 (Khanaychenko and Kovtun, 2009). During 2007-2010 the share of abnormally pigmented specimens of both genders from total number of analyzed BST wild stock varied

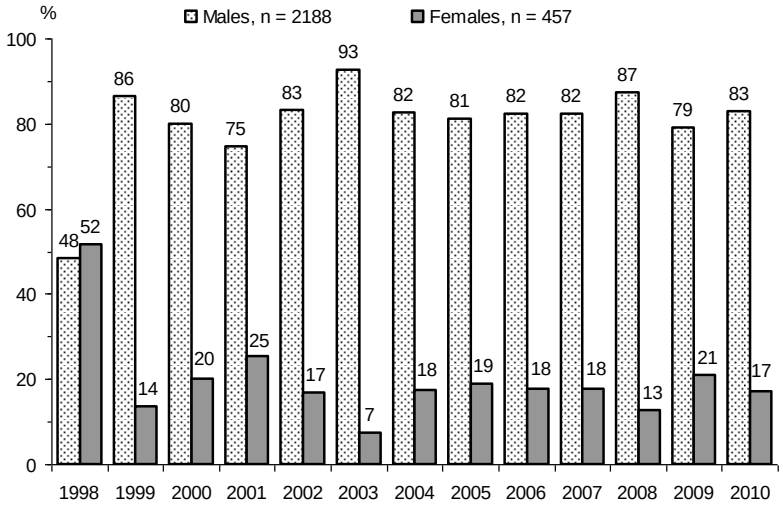

Figure 2. Percentage (%) of males and females in BST spawning population off Sevastopol during April – mid-June periods of 1998-2010.

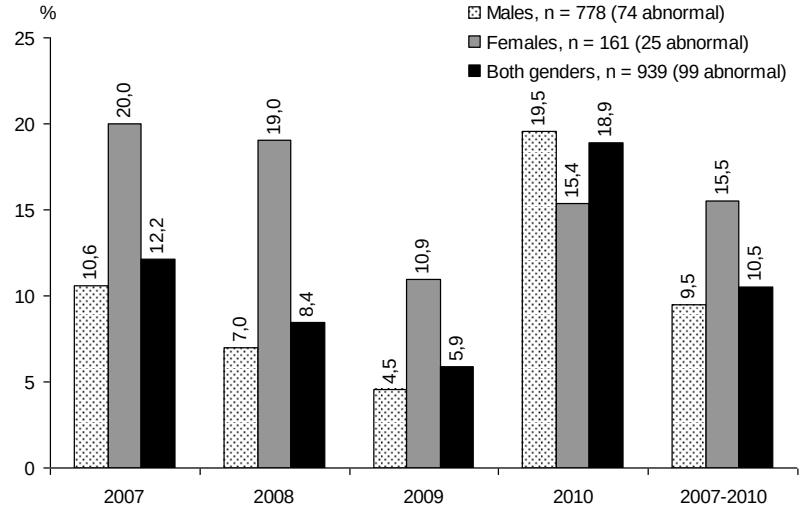

Figure 3. Share (%) of pigmentation abnormalities in males, females, and both genders groups (percentage of total specimens' number) in BST spawning population off Sevastopol during April – mid-June periods of 2007-2010.

from 8.4 to 18.9% (Figure 3). Among females share of malpigmented specimens of all grades (1-6) was 10.9-20.0% and among males those ranged within 4.5–19.5%. Frequency diagram of 6 grades of hyperpigmentation (Figure 4) showed that in both genders share of grade decreased from grade 1 (32.3% from all malpigmented specimens) to grade 6 (6.1%). Among abnormally pigmented females, grade 1 (48%) dominated; grades 2-5 were found less often than in males; and no females were found among grade 6. Among abnormally pigmented males practically equal share of grades 4-5 (each 10.8%) was registered, and grade 6 (complete ambicoloration) was represented only by males (8.1%). Abnormal pigmentation grade 6 (all male) coincided with incomplete right eye migration (eye is located in the profile of the head). Other development anomalies such as different kinds of vertebral column anomalies and various deformities of the jaws, including pugheadedness were registered in BST during 1998-2010 but they appeared in minor part of population.

Monitoring of various externally visible diseases in BST revealed the presence of different injuries. High quota of ulcerated specimens (different grades of skin ulceration grades – presence of hemorrhagic ulcers-different location) were found varying during different years about 14.7-20.2% in male group and 17.9-22.2% in female group and averaged for total population as 15.7-20.4%) (Figure 5). Irregular ulcers appeared at the base of the fins, on the operculum, on

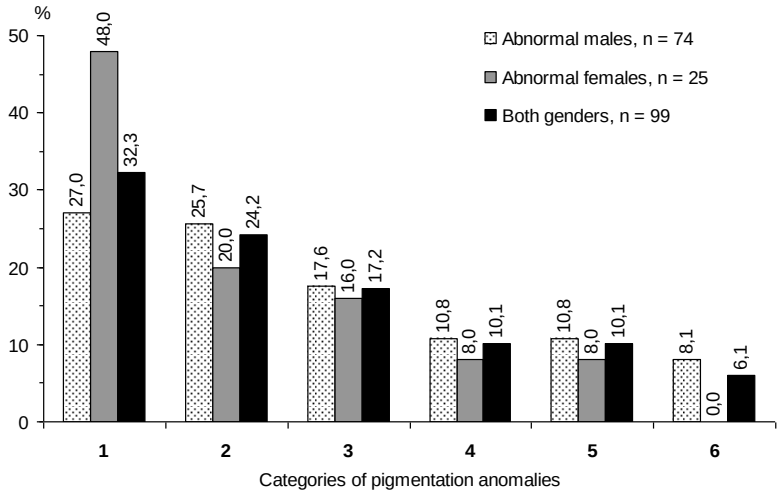

Figure 4. Share (%) of pigmentation abnormalities (categories - from weak - 1 – to strongest - 6 – see explanation in text in males (% from total number of abnormally pigmented males), females (% from total number of abnormally pigmented females), and both genders groups (percentage of abnormally pigmented both genders) in BST spawning population off Sevastopol during April- mid-June periods of 2007-2010.

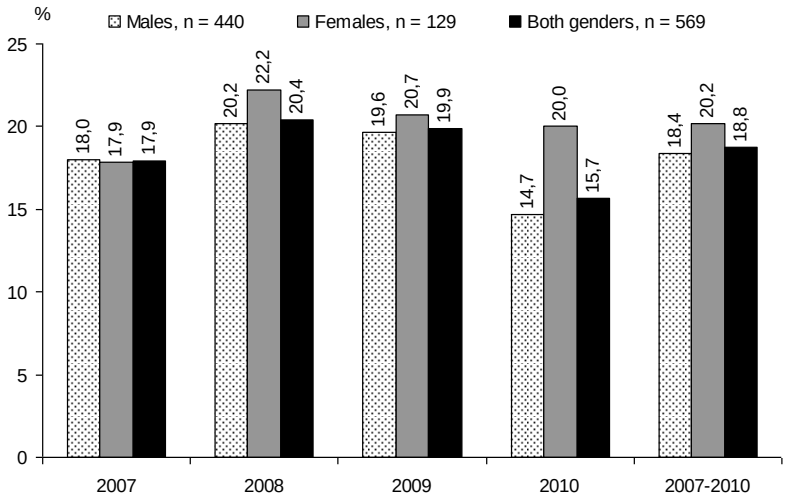

Figure 5. Percentage of hemorrhagic ulcers affection in males (% from total number of males), in females (% from total number of males), and in total population - both sex groups (percentage of total studied fish number) in BST spawning population off Sevastopol during April-June 2007-2010.

the head, and in some specimens tubercles were destroyed and surrounded by hemorrhagic zone. Apart from hemorrhagic ulcers, 4.2-7.2% of BST population was affected by fin rot and about 1% present malignant large tumors mainly on the base of the fins. Etiology of these diseases-bacterial or viral – was impossible to analyze at IBSS NASU.

Discussion

We consider that the landings of the gill net with mesh size of 180-200 mm adequately reflect the size/weight structure of BST spawning population at indicated depths. Fishing efficiency of turbot gill net only can underestimate the smallest sizes (thus youngest) of BST spawners. Total lack of females of TL less than 41.4 cm (SL<33.5 cm) in gill net catches indicate that smaller females (presumably immature) prefer to stay at the depths less than 50 m.

Decrease of the BST wild stock mean sizes and weight during 1998-2008 to TL 48.2 cm (SL 39.3 cm) and W_{total} 1.97 kg reveals the effect of continuous fishery selection of the largest specimens.

Slight increase of mean TL to 52.1 cm (SL to 42.2 cm), W_{total} to 2.54 kg during 2009-2010 could be supposed either as a result of partial population replacement due to various range of migration of different BST size groups, or could be considered as a result of reduced fishery pressure due to relocation of the largest Ukrainian fishery company to the N-W off Crimea before this period.

We made an attempt to compare our data on BST spawning population in Sevastopol sector with the data on BST groups caught by artisanal bottom turbot gill nets in 2001 in Sinop region (Samsun *et al*., 2007), those caught by scientific trawls in 2008 in Trabzon region (Sahin and Gunes, 2011) and in 2006 in Bulgarian sector (Panayotova and Todorova, 2008). Our data on BST populations in Sevastopol region could be compared with those only with a large assumption, as the fishing efficiencies of trawling are wider, especially for smaller specimens. We have chosen the data of 2010 as the indicators of to date BST state-of-art, and compare our data only for sizes limiting genders.

During the last scientific survey of BST in Sevastopol region in spring 2010 individuals of absolute length <41.3 cm were only males and individuals larger than 62.5 cm were only females, and the largest absolute length of BST (female) observed was 74.5 cm. In Bulgarian sector (spring 2006) individuals of absolute length <40.5 cm were predominantly male, individuals larger than 65.5 cm were only females, and the largest absolute length of BST (female) observed was 77.5 cm. According Turkish data in Sinop region in 2001 (Samsun *et al*., 2007) individuals of absolute length <31.8 cm were only males, larger than 69 cm were only female, and the largest absolute length of BST (female) observed was 81 cm (considered to be the largest absolute length recorded since 1990s). Observed in trawl (14 mm codend) catches of BST in Trabzon region in 2008 maximum total length of BST male was 64 cm, of female – 75.3 cm (Sahin and Gunes, 2011), that is close to maximum size of BST-74 cm, observed during study on selectivity of BST gill nets (Erdem, 1996). To sum up, on the basis of this comparison we can conclude that during the last decade the BST sizes in Sevastopol (Ukrainian) area were represented by smaller sizes than in catches in Bulgarian, Turkish sector. Our conclusions are in agreement with length growth analysis (Raykov *et al*., 2008) which showed that BST inhabiting Ukrainian waters reaches the lowest asymptotic length (L_∞ = 74 cm) in comparison with BST inhabiting Bulgarian (L_∞ = 79.26 cm) and Romanian (L_∞ = 76.84 cm) marine areas.

During the last decade (2000-2010) gender ratio (male:female) in Sevastopol BST spawning population was permanently inverse (on average 4.79 : 1). During the favorable for BST 1957–1968 years, the male : female ratio in spawning population on Crimean shelf fluctuated within 0.84 and 1.37 (Popova, 1972). BST spring population in Bulgarian sector in 2006 also presented practically equal (male : female ratio within 0.86-0.96) proportion of genders (Panayotova and Todorova, 2008). In Turkish waters the highest percentage of male BST in the spring was determined to be 62% (Samsun *et al*., 2007), not significantly different from the share of males 66% in gill nets catches (Erdem, 1996). Permanent inverse male: female ratio (mean 4.8:1) in BST spawning population in the coastal region off Sevastopol during 1999-2010 is the evidence of the negative trend of reproductive potential of local population that is about 5 times lower than in populations with equilibrated ratio of genders. Decrease of BST females size leads not only to decrease of number of spawned eggs but also the egg quality. Multiple spawning females not only produce more eggs, but also produce better eggs with higher indices correlated with hatching success and larvae viability (Murawski *et al*., 2001). This postulate is still not proved for BST experimentally, but BST elder females (SL more than 50 cm) are known to produce eggs with significantly higher lipid content than younger ones (SL less than 50 cm) (Popova, 1972).

Based on own experimental data on formation of pigmentation patterns in BST (Khanaychenko and Bityukova, 2007), we considered that high share of pigmentation abnormalities in BST in off Sevastopol (10.5–18.9%) reveals that during early metamorphosis, a significant quota of BST larvae feeding zooplankton prey were not covering their biochemical requirements due to disturbed food web. Disturbances in BST pigmentation, degree of eye migration and skeleton are formed during the larvae development (from start to the climax of metamorphosis and are irreversible after the climax of metamorphosis; own data, unpubl.), remain unchanged through the life span and are the evidence

of unfavourable conditions during early stages. Survival of BST fry with abnormal pigmentation and eye migration in nature is low as they succumb quickly to predators. Vulnerability of BST stock could be affected significantly by composition of the plankton food web which determines substantially the success of BST generation, and thus efficiency of BST reproduction.

About one fifth of BST population in Sevastopol region was considered sick. According Toranzo *et al*. (1993) hemorrhages and ulcerative lesions on different parts of integuments of turbot are the most frequent external clinical signs of diseased fish, and the most prevalent bacteria recovered from diseased turbot are *Vibrio* spp. and *Pseudomonas* spp. Monitoring of diseases of the wild stock in the Turkish Coastal area of the Black Sea also showed 21.2% of diseased BST among the wild BST spawners in 2005 and prevalence of Viral HS among them (Nishizawa *et al*., 2006) that was confirmed by recent survey of VHS in Turkey (Işıdan and Bolat, 2011). High level of diseased fish in BST stock could be related to combination of permanently acting stress environmental factors conjugated with different types of pollution, including chemical and organic agents; with permanent destruction of nursery, stock feeding and spawning grounds through different anthropogenic activities on the shelf and deep water environment; and thereafter permanent stress reducing its immune defense system and contamination by various pathogens (both bacterial or virus origin).

Our data confirm the last resume of Scientific, Technical and Economic Committee for Fisheries (Daskalov and Ratz, 2011) on overexploitation of BST stock. Although there are some signs of recovery during 2009-2010, the BST population structure off Sevastopol is far from the safe. Multiple anthropogenic and environmental factors are supposed to influence vulnerable structure of BST population, and can lead it to irreversible state. Changes in the plankton food web (decreased zooplankton species and biomass and abnormal microalgae blooms) can affect the norm of development, pigmentation and thus, survival of the BST larvae before and during settlement. Survival and quality of the BST first and second year classes is under non-estimated affect of disastrous increase of constructions on the Crimean coastal line and, thus, continuous destruction of coastal communities conjugated with significant anthropogenic pollution, leading to reduction of nursery and feeding grounds. Systematic disturbances and destruction of BST natural feeding and spawning grounds by bottom trawling of small pelagic fish is undoubted (and not estimated), but signs of significant diseased part of BST population reveals its continuous stress. Continuous selection by fishing practices of larger females and inverse sex ratio can decrease eggs quantity and quality and significantly decrease the BST recruitment.

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