

# The State of Crayfish (Astacidae) Populations in a Certain Area of the Caspian Sea Eastern Coast in 2022

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## ABSTRACT

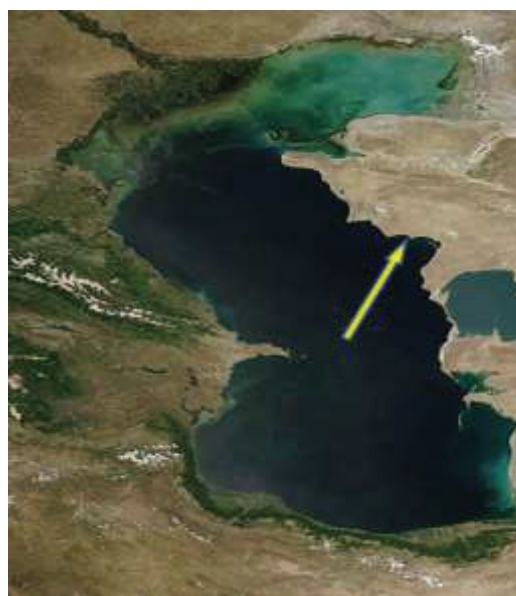
The aim is to study crayfish (*Astacidae*) distribution, fertility and stocks in coastal waters on the Caspian Sea Eastern shelf in the area between cape Rakushechny and cape Tokmak. The research was carried out in summer 2022. The material was collected by shallow-water divers using the method of crayfish route census and selection at the transects with an area of 100-200 m<sup>2</sup>. Collected samples were speciated, measured, weighed and evaluated from fertility viewpoint. Population was estimated on the basis of crayfish clusters density en routes (ind./m<sup>2</sup>) with further re-estimation within biotopes that were identified using the data of the Caspian Sea satellite monitoring and were specified with the help of a drone. The stocks were estimated on the basis of the collected animals' length and weight characteristics. Two *Astacidae* species inhabit the area: *Pontastacus eichwald* Bott – long-clawed crayfish, and *Caspiastacus pachypus* Rathke – thick-clawed crayfish. Comparative analysis of the current results and the data from the 1970s to 1990s has identified that the situation had changed. *C. Pachypus* habitat has expanded. Both *Astacidae* species working fertility has decreased. Crayfish stocks in the researched sector have commercial value. Using data from satellite survey and drone observation increase the research objectivity significantly.

**Keywords:** The Caspian Sea, crayfish, distribution, species composition, biological characteristics, the stocks commercial and economic value, allowable catch limits.

## 1. INTRODUCTION

Crayfish (*Astacidae*) inhabit all the areas of the Caspian Sea [1, p. 32-37; 2, p. 265-266; 3, p. 57]. They are especially widespread on the Eastern shelf of the Caspian Sea middle and southern parts [4, p.59; 6, p. 50-51]. Two species may be found there: *Pontastacus eichwald* Bott – long-clawed crayfish, and *Caspiastacus pachypus* Rathke – thick-clawed crayfish [1, p. 32-37; 2, p. 265-266; 4, p. 69]. In the period of

the sea level rise with the maximum recorded in 1990s the tendency of *C. Pachypus* population increase had been noticed in the Eastern shelf coastal area [6, p. 155-157]. Since then the populations state hadn't been studied for 20 years. Regular research was resumed only in 2015-2019 [8, p. 232-236; 9, p. 8-17; 10, p. 28-36]. The observations made in June 2022 indicate the changes in *Astacidae* populations.



**Figure 1.** The research area



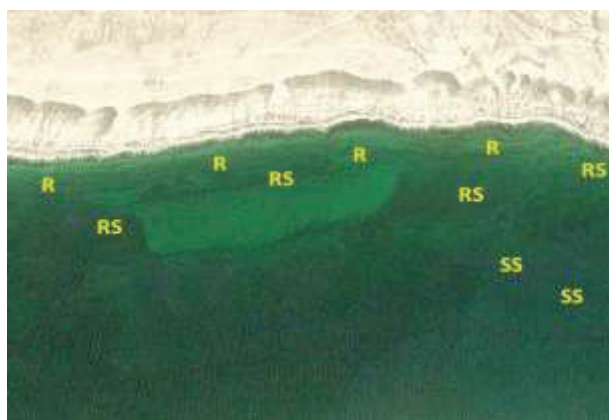
**Figure 2.** The research sector

## 2. MATERIALS AND METHODS

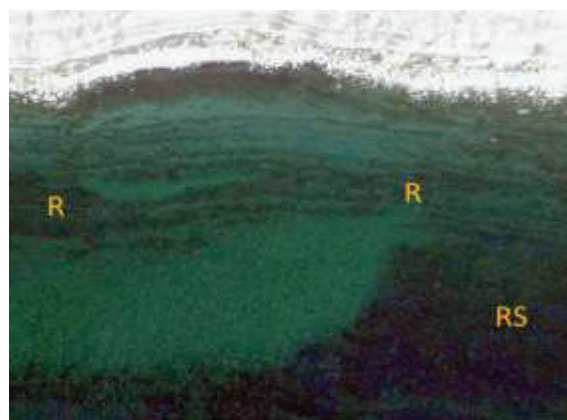
The work was aimed at assessing crayfish populations state, their economic value and commercial stocks. The research objectives were to study biotopes, to identify fishing areas, to consider crayfish distribution at various depths, crayfish species, sex, length and weight composition, working fertility, stocks and catch level. The research was carried out in June 2022 in coastal waters of the Caspian Sea Eastern shelf between cape Rakushechny and cape Tokmak (Fig. 1; 2). Crayfish samples were collected at transects (seabed sectors) with an area of 100 m<sup>2</sup> using aqualungs [6, p. 155-157; 7, p. 884-891; 9, p. 8-17]. For this purpose, a cord with a length of 50 m was laid on the seabed and fixed with anchors on its ends. Then, 2 shallow water divers carried out route census and collected crayfish on the seabed strip with a width of 1 m to the right and left of the cord. When the number of crayfish collected was insufficient (less than 5), divers carried out 2 route census with a total area of 200 m<sup>2</sup>. The coast sector was divided on 10 stations (Fig. 2). 32 transects were defined at the stations. Total processed area was 3200 m<sup>2</sup>. 557 crayfish samples were collected. The crayfish samples delivered on a ship

were speciated. The samples length was measured from rostrum to telson. The samples with a length more than 10 cm were considered commercially valuable. The samples were weighed. The molting phase was identified on the basis of the crayfish shell state. Females working fertility was determined on the basis of the quantity of eggs on pleopods. Then, crayfish samples were released into the sea. Water temperature was measured (surface/seabed), the biotopes physiognomic characteristics were noticed. The stocks were assessed on the basis of the following data: crayfish average quantity (ind./m<sup>2</sup>), average weight of 1 sample and useful area of the researched sector in hectares. TAC – total allowable catch for crayfish is established at the level of 25% of stocks.

Selecting research stations, setting out transects, determining biotopes useful areas were carried out on the basis of the coastal zone satellite images. The station location was specified using a drone that helps to identify physiognomic characteristics of the seabed and to compare them with the satellite data. It is exemplified by the station No. 8 seabed structure (Fig. 3; 4).



**Figure 3.** Satellite image of the station No. 8 location



**Figure 4.** Aerial photograph of the station No. 8 location

The biotopes area was calculated on the basis of satellite images with accurately indicated physiognomic characteristics of the seabed at a depth up to 10-12 m. In order to do that the coastal waters sector was composed from separate images. Then

**Crayfish biotopes.** The researched areas were divided into 3 types of biotopes. The first biotope is represented by rocky ground composed of shell stone plates and its blocks (rock, R). Such ground contour provides most hiding spots for crayfish. The stations No. 5-10 were represented by such ground with rocky ridges with a length of 20-500 m and more. It may be seen in the images in the form of parallel formations (Fig. 4). The total area of this ground constitutes 300 ha. The second biotope is represented by rocky and sandy ground (RS). Such ground lies between rocky ridges of the seabed. Crayfish inhabiting RS use plates and stones blocks as hiding spots. RS may be seen in the images as light seabed areas with dark formations (Fig.3). The total area of this ground constitutes 350 ha. The third biotope is represented by silt-sand ground (silt-sand, SS) covered with vegetation of sea grass *Zostera nana*. This type of ground is widely spread at the stations No. 1-5. SS may be seen in the images as

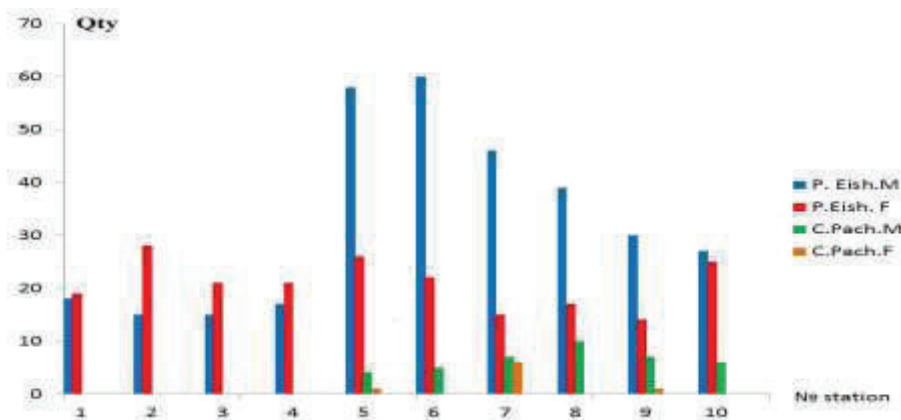
separate biotopes areas were defined graphically in each image. Next, the biotopes areas were calculated using a measuring grid with a square area equal to 1 ha. The data was summed to get the total area of each biotope in hectares.

### 3. THE OBTAINED RESULTS AND THEIR DISCUSSION

round-shaped dark spots (Fig.3). The total area of such biotopes constitutes 230 ha.

**Environmental conditions.** Environment temperature is a key factor that influences crayfish biology and distribution [2, p. 265-266]. The researched area is located in the zone of active upwelling. Water surface temperature measured at a depth of 5-7 m on June 12-20 ranged from 16 to 20°C. A thermocline with temperature equal to 15/10°C was recorded at a depth of 8-9 m. At the station No. 10 – cape Tokmak – the upwelling zone ended and water temperature increased up to 23-25°C. In this point, the eggs on crayfish females' pleopodes were at hatching and larval stages. 30% of crayfish males were at after-molting stage.

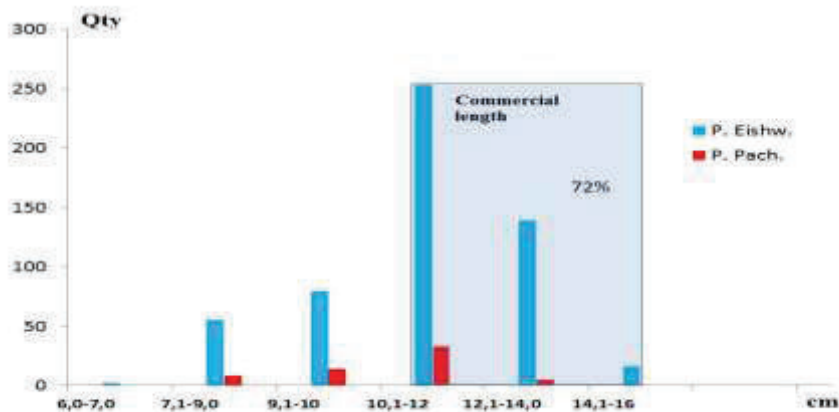
**Crayfish distribution.** *P. eichwald* prevailed in the studied area. Among 557 crayfish samples collected at 10 stations 44 there were 44 *C. pachypus* samples and 513 *P. eichwald* ones. Stations No. 1-4 (SS) were inhabited only by *P. eichwald* (Fig. 5).



**Figure 5** Species and sex composition of crayfish collected at the stations No. 1-10

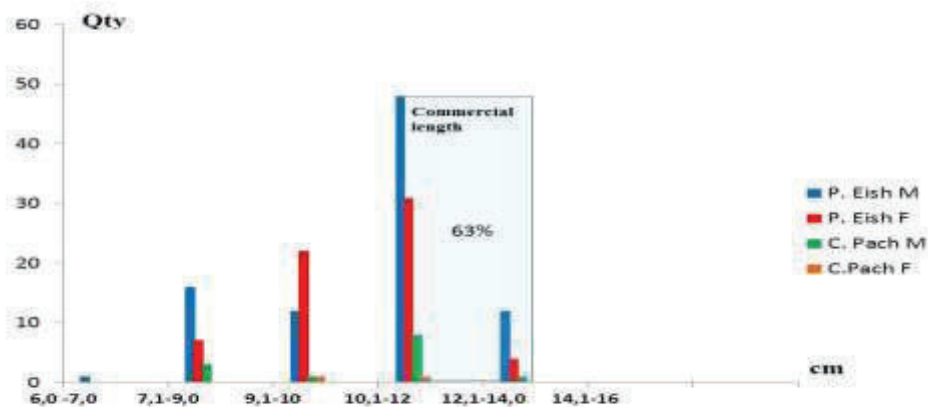
Crayfish distribution on hard ground (R) was uneven. The clusters density was determined by the number of hiding spots in the form of splits, cracks, rock shelters, holes under plates, etc. Crayfish distribution on rocky and sandy (RS) ground was mosaic. This biotope crayfish clustered under the

blocks of shell stone plates. Silt-sand (SS) crayfish made burrows under plants roots and used sea grass vegetation as a hiding spot. Their distribution was the most even. The collected crayfish were divided into 6 size groups. The samples with a length of more than 10 cm were considered commercially valuable (Fig. 6).



**Figure 6.** Length frequency of crayfish collected at the stations No. 1-10

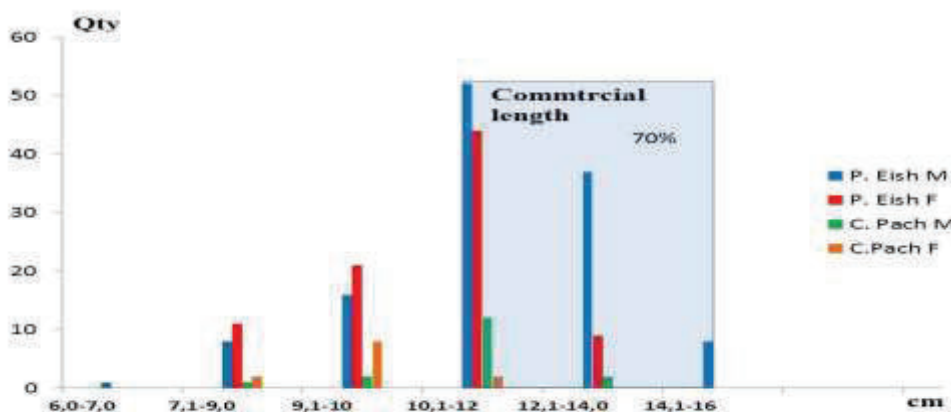
At a depth of 5-7 m commercially valuable part of population constituted 63% and was represented mainly by small and medium-sized samples (Fig. 7).



**Figure 7.** Length frequency of crayfish males and females at a depth of 5-7 m

The depth of 8-10 m was inhabited by larger crayfish. Commercially valuable part of population increased and constituted 70%. The number of

medium-sized and large samples increased significantly (Fig. 8)



**Figure 8.** Length frequency of crayfish males and females at a depth of 8-10 m

The two species largest samples, primarily males, were found at a depth greater than 10 m (Fig. 9). In this area, the greatest quantity of *C. Pachypus* males was recorded.

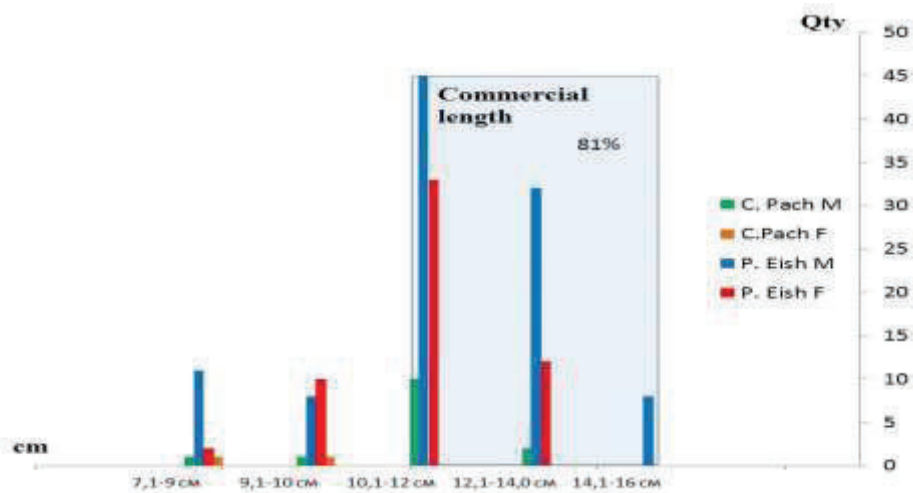


Figure 9. Length frequency of crayfish males and females at a depth greater than 10 m

**Fertility.** The minimum length of *P. eichwald* mature females was 7.8 cm, maximum length – 14.0 cm. The minimum length of *C. pachypus* mature females was 9 cm, maximum length – 10.5 cm. *P. eichwald* fertility ranged from 27 to 211 eggs

depending on the body length with average number of 110 eggs (110±3.35; Fig. 10). *C. pachypus* fertility ranged from 11 to 26 eggs with average number of 19 eggs (19.16±2.62, Fig. 11).

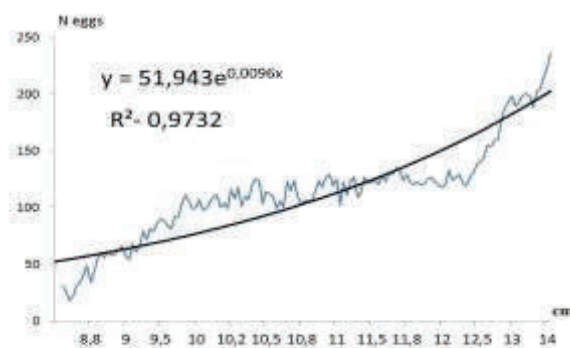


Figure 10. *P. eichwald* working fertility

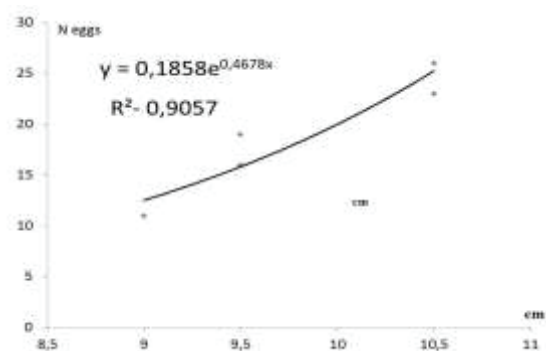
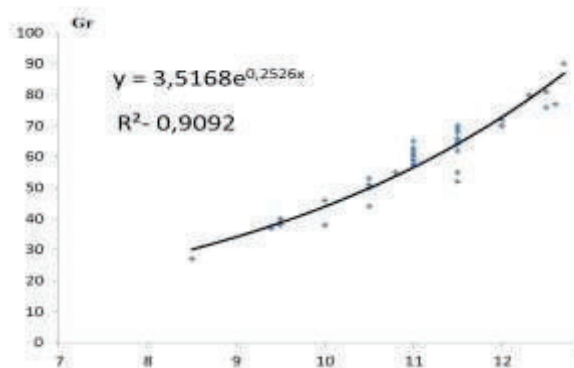
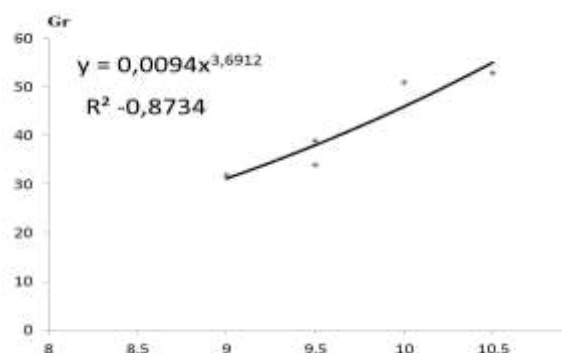
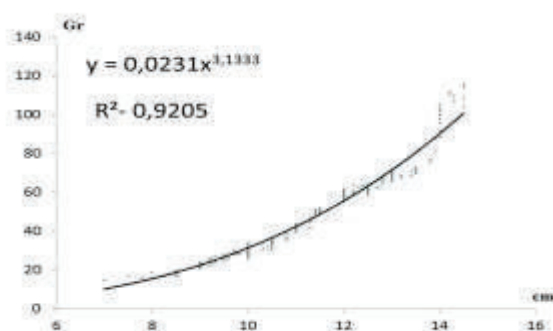
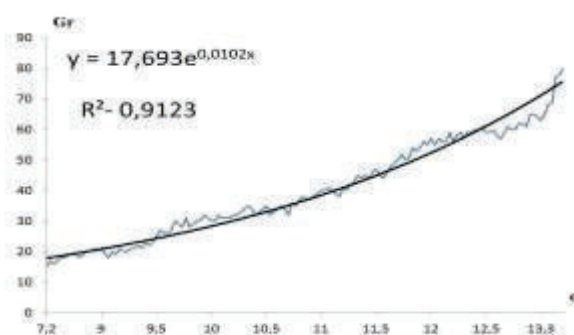


Figure 11. *C. pachypus* working fertility

**Crayfish weight.** Studying *C. pachypus* weight characteristics showed that male average weight was 59 g (59.2±2.07), female average weight was 42 g

(41.8±4.3), (Fig. 12; 13). *P. eichwald* male average weight was 65 g (64.7±2.03), female average weight was 40 g (40.1±1.35) (Fig. 14; 15).



Figure 12. *C. Pachypus* male weightFigure 13. *C. Pachypus* female weightFigure 14. *P. eichwald* male weightFigure 15. *P. Eichwald* female weight

**Commercial stocks calculation.** Total biomass was calculated on the basis of crayfish average quantity (ind./m<sup>2</sup>), average weight of 1 sample and useful area of the studied sector in hectares.

The area of the rocky ground biotope (R) is 300 ha. *P. eichwald* average quantity is 0.16 ind./m<sup>2</sup> or 1600 crayfish samples per 1 ha. Considering that female to male ratio is 30% to 70%, 1 hectare is inhabited by 480 females and 1120 males. With crayfish male average weight equal to 65 g, their total biomass is 72.8 kg/ha, and with crayfish female average weight equal to 40 g, their total biomass is 19.2 kg/ha. In total, *P. eichwald* biomass constitutes 92 kg/ha. *P. eichwald* total biomass in this biotope with an area of 300 ha will be 27.6 t. In accordance with length frequency analysis 72% of *P. eichwald* population are commercially valuable crayfish (longer than 10 cm) that means 19.8 t of biomass. In case of reasonable fishing, TAC as usually will constitute 25% or 4.9 t.

The relevant calculation made for *C. pachypus* has indicated that 1 ha is inhabited by 300 crayfish samples

with the average quantity of 0.03 ind./m<sup>2</sup>. Considering that female to male ratio is 15% to 85%, 1 ha is inhabited by 45 females and 255 males. With crayfish male average weight equal to 59 g, their biomass is 15 kg/ha. With crayfish female average weight equal to 42 g, their biomass is 1.9 kg/ha. *C. pachypus* total biomass constitutes 16.9 kg/ha, and as for rocky biotope (R) with an area of 300 ha – 5.1 t. In accordance with length frequency analysis 63% of *C. pachypus* population are commercially valuable crayfish (longer than 10 cm) that means 3.2 t of biomass. In case of reasonable fishing, TAC will constitute 25% or 0.8 t.

The area of the rocky and sandy biotope (RS) is 350 ha. *P. eichwald* average quantity is 0.18 ind./m<sup>2</sup> or 1800 ind./ha. Considering that female to male ratio is 27% to 73% 1 ha is inhabited by 486 females and 1314 males. With crayfish male average weight equal to 65 g, their biomass is 85.4 kg/ha. With crayfish female average weight equal to 40 g, their biomass is 19.4 kg/ha. In total, *P. eichwald* biomass is 104.8 kg/ha. *P. eichwald* total biomass in rocky and sandy biotope with

an area of 350 ha is 36.6 t. In accordance with length frequency analysis 72% of *P. eichwald* population are commercially valuable crayfish (longer than 10 cm) that means 26.3 t of biomass. TAC will constitute 25% or 6.58 t.

*C. pachypus* stocks calculation has indicated that 1 ha is inhabited by 300 crayfish samples with the average quantity of 0.03 ind./m<sup>2</sup>. With sex ratio 1/10 there are 30 females and 270 males. With crayfish male average weight equal to 59 g their biomass is 15.9 kg/ha. With crayfish female average weight equal to 42 g their biomass is 1.3 kg/ha. *C. pachypus* total biomass is 17.2 kg/ha, and as for rocky and sandy ground biotope with an area of 350 ha – 6.0 t. In accordance with length frequency analysis 63% of *C. pachypus* population are commercially valuable crayfish (longer

than 10 cm) that means 3,8 t of biomass. In case of reasonable fishing, TAC will constitute 25% or 0.9 t.

Silt-sand ground biotope (SS) took more than 20 km from the station No. 1 to the station No. 5. Its total area is equal to 230 ha. Only *P. eichwald* crayfish inhabit the biotope. The average quantity is 0.07 ind./m<sup>2</sup> or 700 ind./ha. The population females prevail over males. With sex ratio 2/1 female to male percentage is 73/27. Therefore, 1 hectare is inhabited by 511 females and 189 males. With crayfish male average weight equal to 65 g their biomass is 12.3 kg/ha. With crayfish female average weight equal to 40 g, their biomass is 20.4 kg/ha. Total biomass is 32.7 kg/ha. *P. eichwald* total biomass in silt-sand biotope (SS) with an area of 230 ha is 7.5 t. Commercially valuable part (72%) is 5.4 t. TAC will constitute 25% or 1.35 t. General data on the stocks and catch limits is given in Table 1.

**Table 1.** Crayfish stocks and total allowable catch (TAC – 25% of commercial stocks)

Biotope	Rocky ground 300 ha		Rocky and sandy ground 350 ha		Silt-sand ground 230 ha		Total, t
	<i>P. eichwald</i>	<i>C. pachypus</i>	<i>P. eichwald</i>	<i>C. pachypus</i>	<i>P. eichwald</i>	<i>C. pachypus</i>	
<b>Stocks, t</b>							
<b>Total</b>	27.6	5.1	36.6	6.0	7.5	-	76.8
<b>Commercial</b>	19.8	3.2	26.3	3.8	5.4	-	58.5
<b>TAC</b>	4.9	0.8	6.58	0.9	1.35	-	14.5

The research has shown that the sector is inhabited by two *Astacidae* species. Archival data [2, p. 265-266; 4, p. 50-51; 6, p. 155-157] has indicated that in 1970s-1990s only *P. eichwald* lived there. According to historical data [6, p. 155-157] *C. pachypus* population increase in Kazakhstan waters was recorded in the period of the sea level rise (1990-1994). Modern research carried out in the period of the sea level lowering has shown that there is still *C. pachypus* population increase tendency [8, p. 232-236; 9, p. 8-17; 10, p. 28-36], and its habitat in the coastal waters at a depth up to 20 m has expanded to south for more than 100 km. As on 2022 this species may be found in the Kazakh Bay waters.

According to the previous years studies (1972-1994) *P. eichwald* female working fertility ranged from 30-250 eggs with the same body length. Modern research has indicated the number of 27-211 eggs that is slightly lower. *C. pachypus* fertility ranged from 20-50 eggs, modern data – 11-26 eggs that is significantly lower. We consider crayfish fertility decrease, especially for *C. pachypus* species that expands its

habitat actively, to be linked with severe decline of predators: sturgeon, white sturgeon, seals eating crayfish in large numbers. Then, due to that fact *Astacidae* has become a food chain dead end. Therefore, there is an assumption that *Astacidae* quantity is regulated at a population level by the means of their fertility decrease. Sex ratio for both species populations complies with the previous years literature data [1, p. 32-37; 2, p. 265-266; 3, P. 57; 4, p. 50-51].

## CONCLUSION

In general, the researched area may be considered commercially valuable. Route census at the transects has indicated that crayfish clusters shouldn't be fished in the area from cape Rakushechny to south-east up to the latitude 42°51.21 (station No.5) at a depth of 5-20 m as the population is represented mainly by females. According to the observation results approximately 14-15 t of crayfish may be caught annually in the studied area under reasonable catch limit. The most commercially valuable samples inhabit a depth of 10-15 m and deeper.



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**AUTHOR'S CONTRIBUTIONS**

Ushivtsev V. – wrote the paper;  
Galaktionova M. – prepared graphic materials;  
Kotenkov S. – searched for historical data, prepared literature sources review;  
Sinitsyna T. – prepared statistical data.

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