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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Changes in Length-Weight Relationships of Three Different Commercial Sea Cucumber During Processing and Corrected of Fisheries Data

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Abstract: In this study, the length and weight changes of 3 commercial sea cucumbers (*Holothuria tubulosa, Holothuria polii, Holothuria sanctori*) during the boiling, freezing and drying processes were investigated. 200 individuals from each species were sampled with SCUBA diving from Ildır Bay, Izmir, in 2019.Gutted weights and length of each individual were measured after each processing stage (boiling, freezing and drying). Average weight losses between the gutted weight and frozen weight of *H. tubulosa*, *H. polii* and *H. sanctori* were 68.3%, 59.5% and 67.7%, respectively. While the average weight losses between gutted weights and dried weights were 91.3%, 88.6% and 92.6% in the same order. *H. tubulosa*, *H. sanctori* and *H. polii* lost their total length after frozen and dried with 48.7% and 63.6%, 55.3% and 64.9%, 39.8% and 48.3%, respectively. Total production of gutted weight in Turkey was recalculated based on the yield of dried and frozen as 4.705.275 kg. All results obtained were presented for the sustainable management of sea cucumber stocks and quota implementation in Turkey waters.

Keywords: *Holothuria polii, Holothuria sanctori, Holothuria tubulosa,* weight lost during processing.

Ticari Üç Farklı Deniz Hıyarı Türünün İşleme Sırasındaki Boy-Ağırlık Değişimleri ve Düzeltilmiş Avcılık Verileri

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Öz: Bu çalışmada, ticari 3 denizhıyarının (*Holothuria tubulosa, Holothuria polii, Holothuria sanctori*) haşlama, dondurulma ve kurutulma işlemleri sırasındaki boy ve ağırlık değişimleri araştırılmıştır. Bu kapsamda 2019 yılında, İzmir ili Ildır Körfezi'nden üç tür SCUBA yöntemiyle her bir türden 200 birey örneklenerek gerçekleştirilmiştir. Her bir bireyin karkas ağırlığı ile, haşlandıktan, dondurulduktan ve kurutulduktan sonraki ağırlıkları ve boyları ölçülmüştür. *H. tubulosa, H. polii* ve *H. sanctori* türlerinin karkas ağırlıkları ile dondurulmuş ağırlıkları arasındaki ortalama ağırlık kayıpları sırasıyla %68,3, %59,5 ve %67,7 iken, karkas ağırlıkları ile kurutulmuş ağırlıkları arasındaki ortalama ağırlık kayıpları %91,3, %88,6 ve %92,6 olarak tespit edilmiştir. *H. tubulosa* dondurulduktan sonra %48,7 ve kurutulduktan sonra % 63,6 oranında, *H. sanctori* sırasıyla %55,3 ve %64,9, *H. polii* %39,8 ve %48,3 oranında boy kaybına uğramaktadırlar. Türkiye'deki toplam üretim miktarı, karkas ağırlık kayıplarına göre yeniden hesaplandığında 4.705.275 kg olarak belirlenmiştir. Elde edilen bu sonuçlar Türkiye'deki denizhıyarı stoklarının sürdürülebilir yönetimi ve kota belirleme işlemleri için ilgili bakanlığa görüş olarak sunulmuştur.

Anahtar kelimeler: *Holothuria polii, Holothuria sanctori, Holothuria tubulosa,* işleme sırasındaki ağırlık kayıpları.

INTRODUCTION

Invertebrate echinoderm sea cucumbers occur in many marine ecosystems, but they are mostly distributed in tropical shallow water and coral reef areas. These organisms can be found from the shallowest areas to the deepest points of marine benthic ecosystems (Gilliland, 1993). Although there are about 1200 sea cucumber species in the world seas, only about 60 species have been commercially fished (Conand, 1990; González - Wangüemert et al., 2014). There are 9 sea cucumber species in Turkish coast and 4 are commercially traded (Aydın, 2008; Aydın, 2013; Aydın, 2016; Aydın et al., 2019).

Sea cucumbers are fished with air supplied diving and free diving or SCUBA diving methods in the Aegean Sea of Turkey. Fisheries of this species are prohibited by other methods (BSGM, 2016).

There is no domestic consumption of sea cucumbers and therefore they are exported as fresh, frozen, dried, salted or smoked to the Far East (China and Singapore) and United States (Aydın, 2008; Aydın et al., 2011; TURKSTAT, 2020). In terms of global scale, Indonesia has the biggest sea cucumber production.

In Turkey, legal regulations such as fishing area, fishing periods, fishing methods and fishing permissions of sea cucumbers have been made by General Directorate of Fisheries, the Ministry of Agriculture and Forestry every 4 years since 2008. In this context, sea cucumber fisheries can only be made in Aegean Sea and fishing areas are divided into two regions, the Southern and Northern Aegean Sea and fisheries are permitted at the basis of fallow method (Aydın, 2008; Aydın, 2017; BSGM, 2016). With the last interim regulation, the quota application was started and the sea cucumber fisheries period was narrowed between January 01 and May 31 for 2020 season with a quota amount of 2500 tons (gutted weight). As of September 2020, 4-years regulation will be made (BSGM, 2019).

Sea cucumber production in Turkey has increased year by year and all production has been exported. Illegal export is almost nonexistent and it is known that only small amounts were exported abroad without any complaints, known as "suitcase trade" (personal observations; Dr. Mehmet AYDIN). Current production and export quantities in Turkey are given in Table 1.

Estimating the amount harvested from the wild was especially difficult since sea cucumbers were exported semi-processed (salted, pickled, smoked etc.) or dried. Therefore, the amounts of total weight harvested from the stock are not known.

In the present study, changes of length and weight of sea cucumber commercially caught and exported during processing were studied with an aim to provide basic data that are required by the concerned ministry to make legal regulations. Moreover, 2020 national quota amount was established based on the data obtained by this study.

Table 1. Sea cucumber production and export amounts by years in Turkey (TURKSTAT, 2020).

Years	Total (kg)	Dried* (kg)	Frozen (kg)
2008	33.669	789	32.880
2009	37.976	7.036	30.940
2010	97.183	16.203	80.980
2011	479.985	13.930	466.055
2012	447.644	27.479	420.165
2013	254.226	21.465	232.761
2014	247.585	23.585	224.000
2015	270.270	51.300	218.970
2016	378.883	74.654	306.229
2017	824.292	130.062	694.230
2018	943.585	141.841	801.744
2019	1.292.121	122.271	1.169.850

*Dried, salted, pickled, smoked.

MATERIAL AND METHOD

A total 200 specimens from each species were collected in 2019 by SCUBA diving method from Ilıca Bay, İzmir and delivered alive to the laboratory in plastic barrels filled with sea water (Figure 1).

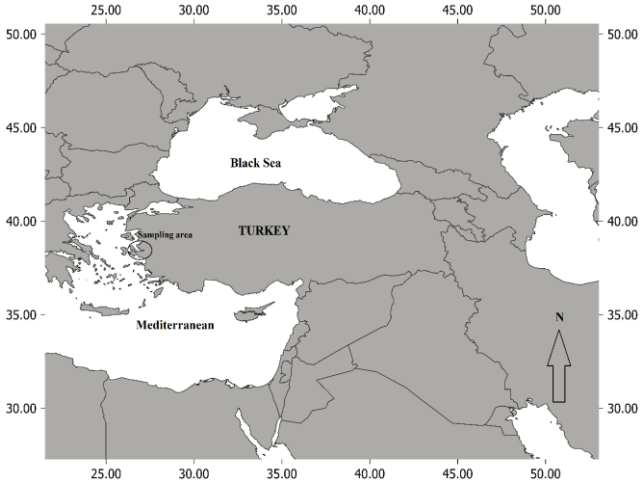

Figure 1. Sampling area.

Wet weights of sea cucumbers can change depending on visceral and internal fluid ejections under stressful conditions and sediment amounts in their body. For this reason, gutted weight is the most reliable morphometric measurement (Aydın & Erkan 2015; Dereli et al., 2016; Aydın, 2020). Thus, gutted weights (GW) of all individuals sampled in the present study were determined in every stage with a precision of 0.01 g. Length and thickness measurements were done using a caliper to a nearest 0.01 cm. All gutted samples were boiled at 100–120°C for about 30 minutes and 100 samples were left in sunlight (72 hours) for dry products while for frozen products, the samples (remaining 100) were first subjected to -40°C and then stored at -18°C (72 hours) Every stage of these processes, the measurements were recorded.

Relationships between gutted length (GL) and weight (GW), boiled length (BL) and boiled weight (BW), frozen length (FL) and frozen weight (FW), dried length (DL) and dried weight (DW) were examined with a nonlinear method $W = aL^b$ whereas those between boiled length (BL) and boiled thickness (BT), frozen length (FL) and frozen thickness (FT), dried length (DL) and dried thickness (DT) were tested with a linear model, Y= ax+b.

Whether the difference between the processing methods, because it is variable length and thickness, the analysis was only according to weight. Kolmogorov-Smirnov Test was applied to all data to determine the distribution before comparing the methods. According to the test results, it was determined that there was no normal distribution and Kruskal Wallis and Mann Whitney-U Tests, which are non-parametric comparison tests, were used (Aydin et al., 2014; Aydın et al., 2020).

RESULTS

The highest average gutted length and gutted weight among three species studies was in *H. sanctori* with 20.8 cm and 142.0 g while the lowest values in *H. polii* with 11.8 cm and 44.4 g (Table 2).

Table 2. Average gutted length and weight of sampled species in the study.

Species	N	L (cm)		W (g)	
		Mean±SE	Min - Max	Mean±SE	Min - Max
H. tubulosa	200	15.6 ± 2.88	9.0 - 25.0	57.3 ± 22.77	19.0 - 134.0
H. polii	200	11.8 ± 2.00	8.0 - 21.5	44.4 ± 16.05	12.0 - 104.0
H. sanctori	200	20.8 ± 3.01	13.3 - 29.5	124.0 ± 28.04	54.0 - 203.0

N: number of samples,L: gutted length, W: gutted weight, Min: Minimum, Max: maximum, SE: Standard error.

Length-weight relationships of sea cucumber species was estimated the highest "b" value for *H. sanctori* (1.8444) and the lowest for *H. polii* (1.1922) (Table 3), suggesting that growth was negative allometric for three species (b<3).

Table 3. Parameters of gutted length - weight relationships of three sea cucumber species.

Species	N	a	b	Correlation
H. tubulosa	200	1.2094	1.3864	$r^2 = 0.4662$
H. polii	200	3.2663	1.1922	$r^2 = 0.5117$
H. sanctori	200	0.4503	1.8444	$r^2 = 0.7086$

N: number of samples, a and b: Regression parameters.

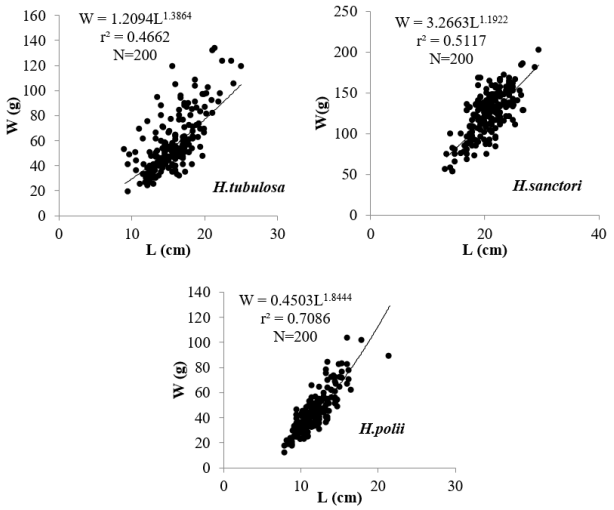

Figure 2. Gutted length - weight relationships of 3 sea cucumbers.

In the present study, weight losses after processing methods were recorded separately by species and length - weight and length - thickness relationships were tested in the resulting samples at each step.

Holothuria tubulosa: Loss of average size after boiling in *H. tubulosa* was from 15.6 ± 2.9 cm to 8.0 ± 1.4 cm with a percentage of 48.7, which was similar to that of freezing loss. Samples that were frozen after boiling shrunk to 5.7 ± 0.9 cm by a decrease of 63.6% (Table 4).

Table 4. Mean length and weight of *H. tubulosa* for each processing stage.

Process	Length (cm)			Weight (g)		Thickness (cm)	
	N	Mean±SE	Min - Max	Mean±SE	Min - Max	Mean±SE	Min - Max
Boiled	200	8.0 ± 1.42	4.5 - 12	19.9^a ± 8.9	6.0 - 51	1.8 ± 0.28	1.2 - 2.5
Frozen	100	8.0 ± 1.52	4.2 - 11.6	20.0^a ± 9.22	6.4 - 48.8	2.0 ± 0.33	1.4 - 2.8
Dried	100	5.7 ± 0.89	3.3 - 8.8	4.5^b ± 1.78	1.4 - 10.6	1.5 ± 0.29	1.0 - 2.4

N: Number of samples, Min: Minimum, Max: maximum, SE: Standard error. There is no statistical difference between those with the same superscript letters (p>0.05).

Relationships of BL - BW, FL - FW and DL - DW in *H. tubulosa* were represented with nonlinear r power models but those between BL and BT, FL and FT, and DL and DT by linear models. The highest correlation was between FL and FW with r^2 =0.7857. Processed materials by boiling and freezing were more stable, which reflected to their better correlations. However, after drying, remarkable changes occur in size and thickness in the samples due to the water losses which was clearly observed poor relationship between DL and DT (Table 5).

Table 5. Parameters of relationships of boiled, frozen and dried samples of *H. tubulosa.*

Process	N	Relation model	a	b	Correlation
BL - BW	200	NL	0.2639	2.0506	r^2 =0.7276
FL - FW	100	NL	0.2834	2.0212	r^2 =0.7857
DL - DW	100	NL	0.1751	1.8345	r^2 =0.5977
BL - BT	200	L	0.7817	0.1238	r^2 =0.3954
FL - FT	100	L	0.7474	0.1534	r^2 =0.5011
DL - DT	100	L	0.7462	0.1359	r^2 =0.1696

BL: Boiled length, BW: boiled weight, FL: Frozen length, FW: Frozen weight, DL: Dried length, DW: Dried weight, BT: Boiled thickness, FT: Frozen thickness, DT: Dried thickness, N: number of samples, a and b: Regression parameters, NL: Nonlinear, L: Linear.

Holothuria sanctori: Average fresh gutted length of *H. sanctori* (20.8 ± 3.01 cm) decreased by 52.9% after boiling and 55.3% after freezing to 9.8 ± 1.2 and 9.3 ± 1.1cm respectively. The samples that were sun - dried lost 64.9% of their size and shrunk to 7.3 ± 1.0 cm (Table 6).

The highest correlation coefficient was observed between FL and FW with r^2 =0.8739, as was in *H.tubulosa*. The relationship of FL - FW had the biggest b value (2.1570).The poorest relation was detected once again between DL and DT (r^2 =0.1442) (Table 7).

Table 6. Mean weight and length of *H. sanctori* for each processing stage.

		Length (cm)		Weight (g)		Thickness (cm)	
Process	**N**	**Mean±SE**	**Min - Max**	**Mean±SE**	**Min - Max**	**Mean±SE**	**Min - Max**
Boiled	200	9.8 ± 1.17	6.8 - 12.6	40.4^a ± 10.46	13.0 - 65.0	2.4 ± 0.30	1.5 - 3.0
Frozen	100	9.3 ± 1.13	6.5 - 11.6	39.0^a ± 10.09	17.0 - 57.5	2.6 ± 0.29	1.9 - 3.6
Dried	100	7.3 ± 1.03	4.7 - 9.3	9.4^b ± 2.77	3.1 - 16.7	2.2 ± 0.33	1.4 - 3.0

N: Number of samples, Min: Minimum, Max: maximum, SE: Standard error. There is no statistical difference between those with the same superscript letters (p>0.05).

The highest correlation coefficient was observed between FL and FW with r^2 =0.8739, as was in *H.tubulosa*. The relationship of FL - FW had the biggest b value (2.1570).The poorest relation was detected once again between DL and DT (r^2 =0.1442) (Table 7).

Table 7. Parameters of relationships of boiled, frozen and dried samples of *H. sanctori*.

Process	N	Relation model	a	b	Correlation
BL - BW	200	NL	0.3673	2.0455	r^2 =0.7675
FL - FW	100	NL	0.3117	2.1570	r^2 =0.8739
DL - DW	100	NL	0.2984	1.7202	r^2 =0.5960
BL - BT	200	L	0.1203	1.1883	r^2 =0.2241
FL - FT	100	L	0.1570	1.0968	r^2 =0.3781
DL - DT	100	L	0.1225	1.3411	r^2 =0.1442

BL: Boiled length, BW: boiled weight, FL: Frozen length, FW: Frozen weight, DL: Dried length, DW: Dried weight, BT: Boiled thickness, FT: Frozen thickness, DT: Dried thickness, N: number of samples, a and b: Regression parameters, NL: Nonlinear, L: Linear.

Holothuria polii: *H. polii* is the smallest sea cucumber in the region. Average gutted length was 11.8 ± 2.0 cm, which was down to 7.3 ± 1.3 cm by a 38.1% of loss after boiling processes. The loss with further freezing reached to 39.8% and resulted in average length of 7.1 ± 1.1 cm. However, further sun drying the samples increased the loss by 48.3%, which resulted in average size of 6.1 ± 1.2 cm (Table 8).

A high correlation was found between FL and FW as in the other species but opposite to those species, in *H. polii* the strongest relation was observed for DL and DW (r^2 =0.8446). Notwithstanding, the highest "b" value was determined for FL and FW, as was the case for other species (Table 9).

Table 8. Mean weight and length of *H. polii* for each processing stage.

		Length (cm)		Weight (g)		Thickness (cm)	
Process	**N**	**Mean±SE**	**Min - Max**	**Mean±SE**	**N**	**Mean±SE**	**Min - Max**
Boiled	200	7.3 ± 1.31	3.5 - 10.7	19.4^a ± 8.68	5.0 - 59.0	1.9 ± 0.27	1.1 - 2.8
Frozen	100	7.1 ± 1.12	4.9 - 10.3	17.9^a ± 7.39	5.6 - 46.3	2.1 ± 0.28	1.4 - 2.8
Dried	100	6.1 ± 1.16	3.1 - 8.7	5.0^b ± 2.23	1.5 - 14.1	1.8 ± 0.30	1.0 - 2.5

N: Number of samples, Min: Minimum, Max: maximum, SE: Standard error. There is no statistical difference between those with the same superscript letters (p>0.05).

Table 9. Parameters of relationships of boiled, frozen and dried samples of *H. polii*.

Process	N	Relation model	a	b	Correlation
BL - BW	200	NL	0.3894	1.9391	r^2 =0.7542
FL - FW	100	NL	0.2740	2.1024	r^2 =0.6980
DL - DW	100	NL	0.1374	1.9660	r^2 =0.8446
BL - BT	200	L	0.1275	0.9321	r^2 =0.3808
FL - FT	100	L	0.1599	0.9140	r^2 =0.4008
DL - DT	100	L	0.1440	0.8990	r^2 =0.3087

BL: Boiled length, BW: boiled weight, FL: Frozen length, FW: Frozen weight, DL: Dried length, DW: Dried weight, BT: Boiled thickness, FT: Frozen thickness, DT: Dried thickness, N: Number of samples, a and b: Regression parameters, NL: Nonlinear, L: Linear.

Processing losses: Regardless of the species studied in this research, average processing loss was 65.2% in frozen products and 90.9% in dried products. When expressed by species, the losses in frozen products were, 68.3, 67.7 and 59.5% for *H. tubulosa*, *H. sanctori* and *H. polii*, respectively, and in dried products, 91.3, 92.6 and 88.6 %, respectively (Table 10).

Corrected fisheries data: Considering that dried and frozen products represent 9.1 and 34.8% of gutted weight regardless of commercial sea cucumber species, total production quantity of Turkey can be recalculated by years as can be seen in Table 11.

Table 10. Processing losses in frozen and dried products.

	Frozen products				
Species	**N**	**Gutted W (g)**	**Frozen (W, g)**	**Product (W, %)**	**W loss (%)**
H. tubulosa	100	6298	1996	31.7	68.3
H. sanctori	100	12017	3881	32.3	67.7
H. polii	100	4421	1790	40.5	59.5
			Mean	34.8	65.2
			SE	4.9	4.9
Species	**Dried products**				
	N	**Gutted (W, g)**	**Dried (W, g)**	**Product W (%)**	**W loss (%)**
H. tubulosa	100	5160	448	8.7	91.3
H. sanctori	100	12781	941	7.4	92.6
H. polii	100	4461	507	11.4	88.6
			Mean	9.1	90.9
			SE	2.0	2.0

N: Number of samples, W: Weight, SE: Standard error

Table 11. Corrected sea cucumber production amounts by years.

Years	Dried (kg)	Frozen (kg)	Total (kg)	Corrected (gutted) (kg)
2008	789	32.880	33.669	103.153
2009	7.036	30.940	37.976	166.227
2010	16.203	80.980	97.183	410.756
2011	13.930	466.055	479.985	1.492.315
2012	27.479	420.165	447.644	1.509.338
2013	21.465	232.761	254.226	904.733
2014	23.585	224.000	247.585	902.854

2015	51.300	218.970	270.270	1.192.960
2016	74.654	306.229	378.883	1.700.342
2017	130.062	694.230	824.292	3.424.167
2018	141.841	801.744	943.585	3.862.554
2019	122.271	1.169.850	1.292.121	4.705.275

DISCUSSION

Growth of three sea cucumber species was a negative allometry (b<3), which is consistent with the findings of previous studies carried out in the same region (Table 12). In studies conducted other than the Aegean Sea, growth was also given as negative allometry (Venkataraman, 2007; Veronika et al.,2018; Ahmed et al., 2018; Siddique & Ayub, 2019). It is known that organism that are longer than transverse, such as sea cucumbers, show negative allometry (b <3) (Pauly, 1983). Although the number of samples in the present study was relatively small, correlation coefficients between gutted length and weight data are in harmony with other studies (Table 12). Aydın (2020) reported higher "b" values for the same species and same area because of the large number of samples.

Average gutted weights obtained in the present study and former studies are shown in Table 13. The highest and lowest gutted weight for *H. tubulosa* was reported by Kazanidis et al. (2010) in Greek water and Dereli et al., (2016) in Turkish waters, respectively. This species has been commercially caught in Turkey for 30 years (Aydın, 2008) which can explain the reason of why larger individuals are found in Greece where no commercial sea cucumber fisheries are the case.

Table 12. Length - weight parameters of previous studies conducted in the region.

Species	N	b	r^2	Area	References
H. tubulosa (GL - GW)	200	1.3864	0.4662	Aegean Sea	**This study**
H. polii (GL - GW)	200	1.1922	0.5117	Aegean Sea	**This study**
H. sanctori (EL - EW)	200	1.8444	0.7086	Aegean Sea	**This study**
H. tubulosa (GL - GW)	6414	1.7020	0.8330	Aegean Sea	Aydın, 2020
H. polii (GL - GW)	9086	1.8040	0.7120	Aegean Sea	Aydın, 2020
H. tubulosa (EL - EW)	598	1.4300	0.7000	Aegean Sea	Dereli et al., 2016
H. polii (EL - EW)	839	1.0500	0.4500	Aegean Sea	González - Wangüemert et al., 2014
H. tubulosa (EL - EW)	754	1.1400	0.4100	Aegean Sea	González - Wangüemert et al., 2014
H. tubulosa (L - EW)	314	0.8100	0.5800	Aegean Sea	Kazanidis et al., 2010
H. sanctori (EL - EW)	340	1.2900	0.7200	Aegean Sea	Aydın, 2013

Table 13. Average gutted weights of commercial sea cucumbers reported by studies conducted in the region.

Species	N	Mean W (g) (Min – Max)	References
H. tubulosa	200	57.3 (19.0 - 134.0)	**This study**
H. tubulosa	6414	66.34 (7.4 - 225)	Aydın, 2020
H. tubulosa	282	83.8 (25.0 - 159.5)	González - Wangüemert et al., 2016
H. tubulosa	598	49.9 (6.1 - 127)	Dereli et al., 2016
H. tubulosa	754	88.7 (30 - 211)	González - Wangüemert et al., 2014
H. tubulosa	314	108.4 (39.4 - 226.3)	Kazanidis et al., 2010
H. tubulosa	350	61.8 (20.3 - 164.4)	Vafeiadou et al., 2010
H. polii	200	44.4 (12.0 - 104.0)	**This study**
H. polii	9086	49.33 (6.9 - 135.0)	Aydın, 2020
H. polii	312	47.3 (19.8 - 79.1)	González - Wangüemert et al., 2016
H. polii	839	37.5 (17 - 84)	González - Wangüemert et al., 2014
H. sanctori	200	124.0 (54.0 - 203.0)	**This study**
H. sanctori	747	102.34 (33 - 185.9)	Aydın, 2020
H. sanctori	2032	18.1	Navarro et al., 2013
H. sanctori	340	100.5 (51 - 175.7)	Aydın, 2013

N: Number of samples, W: Weight, Min: Minimum, Max: Maximum.

Gutted weights of *H. polii* in the current study are within the range of literature data (Table 3). *H. sanctori*is generally active in the nights. They have an ability to secrete a netted fluid to protect themselves thanks to its cuvier organs when feeling in danger or under stress. Although they are relatively large, the divers did not prefer to collect this species because of this netting that fell into their hands during collection (Aydın, 2013). Yet, recent increase in demand for sea cucumber and commercial value has caused divers to collect this species since 2019. Therefore, since the stock of the species has never been exploited, it is thought that their average weight is higher than other species.

Ram et al. (2016) reported the dried product percentages of gutted for 8 species in Fiji Island (Table 14). Purcell et al. (2009) found the remaining material after drying 11.6% for species of *Holothuria whitmaei*. Pardua et al. (2019) studied the drying loss of *H. scabra* in two regions of Philippines and found the product rate as 8.82% in Coron region and 6.19% in Balinao region (Table 14). In the present study, dried mass was 8.7% of gutted for *H. tubulosa*, 7.4% for *H. sanctori* and 11.4% for *H. polii*, being consistent with the literature findings. In a study

conducted by González - Wangüemert et al. (2019) in Aegean Sea, these yields were calculated as 15.36% for *H. polii* and 10.75% for *H. tubulosa*. The inconsistency of these findings with those in the current study can be explained with differences in study regions and years.

Table 14. Average dried weights of commercial sea cucumbers reported by studies conducted.

Species	Dried product (%)	Location	References
Holothuria scabra	8.1	Fiji Island	Ram et al. 2016
Actinopyga lecanora	9.5	Fiji Island	Ram et al. 2016
Actinopyga mauritiana	5.7	Fiji Island	Ram et al. 2016
Actinopyga miliaris	6.3	Fiji Island	Ram et al. 2016
Bohadschia argus	3	Fiji Island	Ram et al. 2016
Holothuria fuscogilva	10.6	Fiji Island	Ram et al. 2016
Holothuria whitmaei	11	Fiji Island	Ram et al. 2016
Thelenota pineapple	6.5	Fiji Island	Ram et al. 2016
Holothuria whitmaei	11.6	-	Purcell et al. 2009
Holothuria scabra	8.82	Coron Region	Pardua et al. 2019
Holothuria scabra	6.19	Balinao Reg.	Pardua et al. 2019
Holothuria tubulosa	10.75	Aegean Sea	González - Wangüemert et al. 2019
Holothuria polii	15.36	Aegean Sea	González - Wangüemert et al. 2019
Holothuria tubulosa	8.7	Ildır Bay	**This study**
Holothuria sanctori	7.4	Ildır Bay	**This study**
Holothuria polii	11.4	Ildır Bay	**This study**

Based on the yields of dried and frozen products (9.1% and 34.8% respectively), total gutted production caught from the sea were recalculated. The corrected data show that production amount in 2008 with 103,153 kg reached to 4,705,275 kg in 2019 by a 45.6 fold - increase. The Ministry started quota implementation with circular as of January 2020 by taking this increase into consideration. 2020 quota amount has been determined as 2,500,000 kg (as gutted weight) which was shared to companies considering the export rates of previous years (BSGM, 2019). Sea cucumber stock management in Turkish waters as of 2020 can be summarized as the quota application, prohibition of fisheries during reproduction period and regional prohibitions.

Sea cucumber trade in all countries is made in the form of dried, frozen, salted etc. Although there are data on the most traded species, there are limited studies on the Mediterranean species that are gaining importance in the sector. Strict management regulations related to sea cucumber fisheries in the Mediterranean basin has been made firstly for Turkish stocks. The quota regulation put into practice by arrangement in 2020 is a first for management of the Mediterranean stocks.

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REFERENCES

Ahmed, Q., Poot-Salazar A., Ali, Q.M. & Bat, L. (2018). Seasonal variation in the length-weight relationships and condition factor of four commercially important sea cucumbers species from Karachi Coast-Northern Arabian Sea. *Natural and Engineering Sciences, **3***(3), 265-281.

Aydın, M. (2008). The commercial sea cucumbers fishery in Turkey. *SPC Beche de mer Information Bulletin, **28***, 40-43.

Aydın, M. (2013). Some biological characteristics of the sea cucumber *Holothuria (Platyperona) sanctori* Delle Chiaje, 1823 (Echinodermata: Holothuroidea). *Biological Diversity and Conservation, **6***(3), 153-159.

Aydın, M. (2016). Sea cucumber (holothuroidea) species of Turkey. *Turkish Journal of Maritime and Marine Sciences, **2***(1), 49-58.

Aydın, M. (2017). Present status of the sea cucumber fishery in Turkey. *SPC Beche de Mer Information Bulletin, **37***, 30-34.

Aydın, M. (2020). Length-weight relationships and condition factor of four different sea cucumber species in the Aegean Sea. *Journal Anatolian Environment and Animal Sciences, **5***(1), 80-85. DOI: 10.35229/jaes.677940

Aydın, M. & Erkan, S. (2015). Identification and some biological characteristics of commercial sea cucumber in the Turkey coast waters. *International Journal of Fisheries and Aquatic Studies, **3***(1), 260-265.

Aydın, M., Gürlek, M., Samyn, Y., Ergüden, D. & Turan, C. (2019). First record of a lessepsian migrant: the sea cucumber *Holothuria* (*Theelothuria*) *hamata* Pearson, 1913. *Zootaxa, **4551***(1), 94-100.

Aydın, M., Karadurmuş, U. & Tunca, E. (2014). Morphometric aspects and growth modeling of exotic bivalve blood cockle *Scapharca inaequivalvis* from the Black Sea, Turkey. *Biologia, **69***(12), 1707-1715.

Aydın, M., Sevgili, H., Tufan, B., Emre, Y. & Köse, S. (2011). Proximate composition and fatty acid profile of three different fresh and dried commercial sea cucumbers from Turkey.

International Journal of Food Science & Technology, ***46***(3), 500-508. DOI: 10.1111/j.1365-2621.2010.02512.x

Aydın, M., Tunca, E. & Esen-Ersoy, N. (2020). Morphometric Aspects and Growth Parameters of the Wedge Clam (*Donax trunculus*) of the Black Sea, Turkey. *Journal of Anatolian Environmental and Animal Sciences*, ***5***(1), 11-18. DOI: 10.35229/jaes.637729

BSGM. (2016). General Directorate of Fisheries and Aquaculture, Fisheries regulations, 68pp.

BSGM. (2019). General Directorate of Fisheries and Aquaculture, Circular No: 2019/3,7pp.

Conand, C. (1990). *The fishery resources of Pacific island countries. Part 2: Holothurians.* FAO, Rome, 143pp.

Dereli, H., Culha, S.T., Culha, M., Özalp, B.H. & Tekinay, A.A. (2016). Reproduction and population structure of the sea cucumber *Holothuria tubulosa* in the Dardanelles Strait, Turkey. *Mediterranean Marine Science*, ***17***(1), 47-55. DOI: 10.12681/mms.1360

Gilliland, PM. (1993). The skeletal morphology, systematics and evolutionary history of holothurians *Special Papers in Paleontology* ***47***(1), 147.

González–Wangüemert, M., Valente, S., Henriques, F., Domínguez-Godino, J.A. & Serrãoa, E.A. (2016). Setting preliminary biometric baselines for new target sea cucumbers species of the NE Atlantic and Mediterranean fisheries. *Fisheries Research*, ***179***, 57-66. DOI: 10.1016/j.fishres.2016.02.008

González–Wangüemert, M., Aydın, M. & Chantal, C. (2014). Assessment of sea cucumber populations from Aegean Sea (Turkey): First insights to sustainable management of new fisheries. *Ocean & Coastal Management* ***92***, 87-94. DOI: 0.1016/j.ocecoaman.2014.02.014

González-Wangüemert, M., Domínguez-Godino, J.A. & Aydın, M. (2019). Profitability of the Mediterranean and NE Atlantic new target sea cucumber species: some repercussions for their fisheries management. *Indian Journal of Geo-Marine Sciences*, ***48***(11), 1715-1719.

Kazanidis, G., Antoniadou, C., Lolas, A.P., Neofitou, N., Vafidis, D. Chintiroglou, C. & Neofitou, C. (2010). Population dynamics and reproduction of *Holothuria tubulosa* (Holothuroidea: Echinodermata) in the Aegean Sea. *Journal of the Marine Biological Association of the United Kingdom* ***90***(05), 895-901. DOI: 10.1017/S0025315410000251

Navarro, P.G., García–Sanz, S. & Tuya, F. (2013). Patrones de abundancia y talla de *Holothuria sanctori*, *Holothuria mammata* y *Holothuria arguinensis* (Echinodermata: Holoturoidea) en la isla de Gran Canaria, Atlántico oriental. *Revista de Biología Marina y Oceanografía* ***48***(2), 273-284. DOI: 10.4067/S0718-19572013000200007

Pardua, S.N., Lapitan, E.L.O., Deanon, J., Duque, J.A.C., Pangan, R.S. & Yaptenco, K.F. (2018). Product recovery after processing and drying of Philippine Sandfish (*Holothuria scabra*) into trepang. *Philippine Journal of Agricultural and Biosystems Engineering*, ***14***, 31-44.

Pauly, D. (1983). *Some simple methods for the assessment of tropical fish stocks*. FAO, Rome, 52pp.

Purcell, S.W., Gossiun, H. & Agudo, N.S. (2009). Changes in weight and length of sea cucumbers during conversion to processed beche - de - mer: filling gaps for some exploited tropical species. *SPC Beche-de-mer Information Bulletin*, ***29***, 3-6.

Ram, R., Chand, R. V., Zeng, C. & Southgate, P. (2016). Recovery rates for eight commercial sea cucumber species from the Fiji Islands. *Regional Studies in Marine Science*, ***8***(1), 59-64. DOI: 10.1016/j.rsma.2016.09.003

Siddique, S. & Ayub, Z. (2019). To estimate growth function by the use of SLW Index in the sea cucumber *Holothuria arenicola* (Holothuroidea: Echinodermata) of Pakistan (Northern Arabian Sea). *Thalassas: An International Journal of Marine Sciences* ***35***(1), 123-132.

TURKSTAT. (2020). "Sea cucumber trade", https://www.tuik.gov.tr accessed online 13 April 2020.

Vafeiadou, A.M., Antoniadou, C., Vafidis, D., Fryganiotis, K. & Chintiroglou, C. (2010). Density and biometry of the exploited holothurian *Holothuria tubulosa* at the Dodecanese, South Aegean Sea. *Rapport Commission international Mer Méditerranée*, ***39***, 661pp.

Venkataraman, C. (2007). Present status of population of holothurians in India. FAO, Rome, 58pp.

Veronika, K., Edrisinghe, U., Sivashanthini, K. & Athauda, A.R.S.B. (2018). Length-weight relationships of four different sea cucumber species in North-East coastal region of Sri Lanka. *Tropical Agricultural Research* ***29***(2), 212-217. DOI: 10.4038/tar.v29i2.8290