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*Araştırma/Research Article*

# Saros Körfezi (Kuzey Ege Denizi, Türkiye) 'nden Avlanan Kancaağız Pisi Balığı'nın (*Citharus linguatula* Linnaeus, 1758) Büyüme Parametrelerinin Belirlenmesi

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**Öz:** Bu çalışma Eylül 2006-Eylül 2008 tarihleri arasında Saroz Körfezi'nde gerçekleştirilmiştir. Örnekler 0-500 m. arasındaki derinliklerde, aylık olarak, 44 mm göz genişliğine sahip trol ağı kullanmak suretiyle elde edilmiştir. Dişi erkek oranı 1:0,42 olarak hesaplanmıştır. Dişi ve erkek bireyler için boy-ağırlık ilişkisi, sırasıyla, $W = 0,0054TL^{3,11}$ ve $W = 0,0045TL^{3,17}$ 'dir. Büyüme parametreleri dişi bireyler için $L_\infty = 25,6$ cm, $k = 0,24$ yıl$^{-1}$, $t_0 = -1,64$ yıl, erkek bireyler için $L_\infty = 21,7$ cm, $k = 0,29$ yıl$^{-1}$, $t_0 = -1,96$ yıl'dır.

**Anahtar kelimeler:** Yaş, büyüme, *Citharus linguatula*, Saros Körfezi, Kuzey Ege Denizi

## Determination of Growth Parameters of Spotted Flounder (*Citharus linguatula* Linnaeus, 1758) from Saros Bay (Northern Aegean Sea, Turkey)

**Abstract:** The spotted flounder (*Citharus linguatula* Linnaeus, 1758) samples were collected between September 2006-2008 using a commercial bottom trawl net with 44 mm codend mesh size at depths ranging from 0 to 500 m in Saros Bay. The sex ratio of females to males was 1:0.42. The length-weight relationships were $W = 0.0054TL^{3.11}$ for females; $W = 0.0045TL^{3.17}$ for males. The growth parameters were $L_\infty = 25.6$ cm, $k = 0.24$ year$^{-1}$, $t_0 = -1.64$ year for females; $L_\infty = 21.7$ cm, $k = 0.29$ year$^{-1}$, $t_0 = -1.96$ year for males.

**Keywords:** Age, growth, *Citharus linguatula*, Saros Bay, Northern Aegean Sea

## INTRODUCTION

The age information has importance because it forms the basis for the calculations of growth, productivity estimates and mortality rates (Campana, 2001). Therefore, the growth rates are necessary input parameters for stock assessment models and can have a significant impact on the result of the analyses (Karakulak et al., 2011).

The spotted flounder (*Citharus linguatula* Linnaeus, 1758) is a flatfish that is distributed in the Mediterranean Sea and eastern Atlantic (Nielsen, 1986). This specis usually found at depths of 10 to 100 m (Sartor et al., 2002). It is widely distributed in the Mediterranean, including the Aegean Sea and Sea of Marmara and territorial waters of Turkey (Bilecenoglu et al., 2002) and is often discarded from commercial trawl fisheries in Turkish waters (Bayhan et al., 2009).

Throughout the world, the information on the age and growth of species were given by Vassilopoulou and Papaconstantinou (1994) in the Aegean Sea, whereas similar aspects were studied by García-Rodríguez and Esteban (2000) and Teixeira et al. (2010) from the Iberian Mediterranean and the Portuguese coast, respectively. The feeding habits of the spotted flounder from the eastern coast of Spain and the central Tyrrhenian Sea were investigated by Redon et al. (1994) and Carpentieri et al. (2010), respectively. In addition, Sartor et al. (2002) provided the data on the distribution and abundance *C. linguatula* in the Mediterranean Sea.

As to Turkish waters, the some morphometric features of the spotted flounder have been reported by Gürkan and Bayhan (2009) in the Izmir Bay. The growth parameters and spawning period of *C. linguatula* were investigated by Özaydın et al. (2003) and Bayhan et al. (2009) in the Izmir Bay, by Türker Çakır et al. (2005) in the Edremit Bay. Although the preliminary studies concerning length–weight relation (Özekinci et al., 2009), presence (Cengiz et al., 2011), length–otolith size relation (Cengiz et al., 2012a), distribution and abundance (Cengiz et al., 2014a), reproductive biology (Cengiz et al., 2014b) and feeding (Cengiz and İşmen, 2018) of the species has been published previously in the Saros Bay, there was no information on growth parameters of *C. linguatula* until now. The aims of this study were to estimate the growth parameters of the spotted flounder in the Saros Bay and to compare these results with those of the previous studies in other areas.

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**MATERIALS AND METHODS**

Individuals of the spotted flounder were collected, monthly, between September 2006 and September 2008, using a commercial bottom trawl net with 44 mm codend stretched mesh size, at depths ranging from 0 m to 500 m in the Saros Bay (Fig. 1) (Cengiz et al., 2014c; 2015).

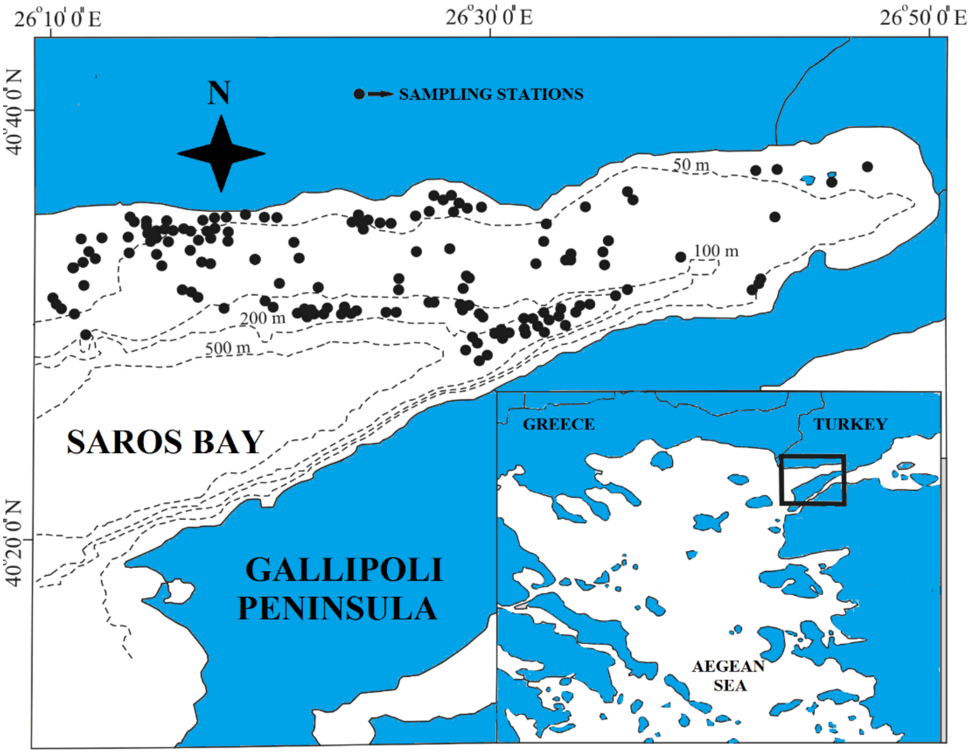

**Figure 1.** Saros Bay and sampling stations.

Total length (TL) of sampled specimens for age determination were measured to the nearest 1 mm and total weight (W) was determined to the nearest 0.01 g. The statistical significance of differences in the sex ratio (female : male) were examined using a chi-square ($X^2$) test. The student's *t*-test was used to analyze the statistical significance of differences in the mean length of the sexes.
Length–weight relationships were determined for males and females according to the equation;
$W = a\,L^b$,
where *W* is total weight (g), *L* the total length (cm), the parameters *a* and *b* were calculated by functional regression, as was the coefficient of determination ($r^2$). The *b* value was tested by *t-test* at a 0.05 significance level to verify the significant difference from the isometric growth ($b = 3$); *a* was the intercept and *b* the coefficient of the functional regression between *W* and *L* (Ricker, 1975).
In flatfishes, the otoliths from blind side were used for age determination, as the nucleus is more central (Fig 2.) and the zones were easier to be interpreted compared to otoliths from the ocular side (Cengiz et al., 2012b; 2014b).

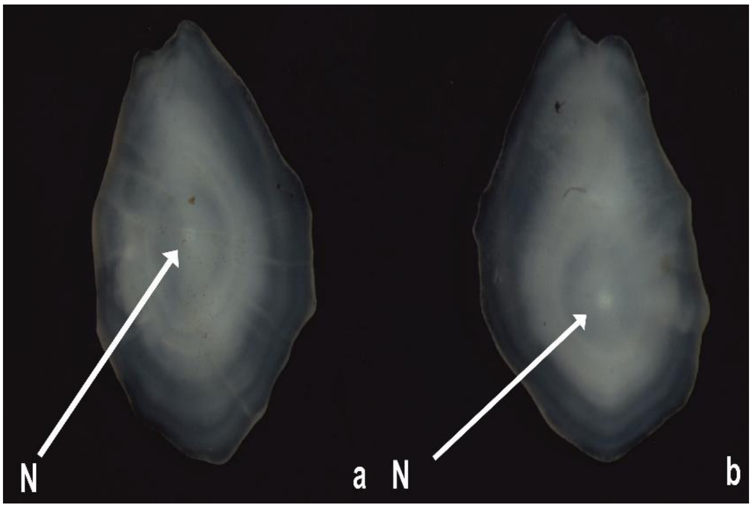


**Figure 2.** Otolith of *C. linguatula*, from Saros Bay, with N indicating the nucleus; otolith from blind side (a), otolith from ocular side of the fish (b) (from Cengiz et al., 2014b)

The blind side otoliths were soaked in 5% HCl and 3% NaOH solutions, then washed in distilled water for 5 min, and subsequently dried. Age determination was performed using a stereoscopic zoom microscope, with the otoliths placed in water under reflected light against a black background. Opaque and transparent zones were counted; one opaque zone together with one transparent zone was assumed to be an age mark (Cengiz et al., 2013a). Counts of rings on the otoliths were blind-read by two readers, who did not know the fish length. All otoliths were read twice and final age estimates achieved when the same results were obtained from the two readers (Ayyıldız et al., 2014). The von Bertalanffy growth equation was used to fit the length at age data using non-linear least squares parameter estimation (von Bertalanffy, 1938);
$L_t = L_\infty [1 - e^{-k(t - t_0)}]$
where $L_t$ is fish length (cm) at age $t$, $L_\infty$ is the asymptotic fish length (cm), $t$ is the fish age (year), $t_0$ (year) is the hypothetical time at which the fish length is zero and $k$ the growth coefficient (year$^{-1}$).

## RESULTS

Of 659 specimens examined by taking sub-sample randomly, 464 (70.4%) were female and 195 (29.6%) males. The sex ratio (F: M) was 1: 0.42. The mean total length and total weight of females were 18.2±0.10 (9.9–23.5 cm), 47.59±0.80 (7.81–102.42 g), of males were 16.6±0.15 (9.4–22.2 cm), 35.64±1.03 (5.08–91.92 g). The student's *t*-test and chi-square analyses showed that mean total lengths and total weights between sexes and the sex ratio were significantly different. ($P<0.05$).
Length-weight relationships were calculated separately for females and males as: $W=0.0054TL^{3.11}$ ($r^2=0.96$) and $W=0.0045TL^{3.17}$ ($r^2=0.96$) (Fig 3). The *b*-values and *t*-test results indicated a positive allometric growth for both sexes ($P>0.05$).

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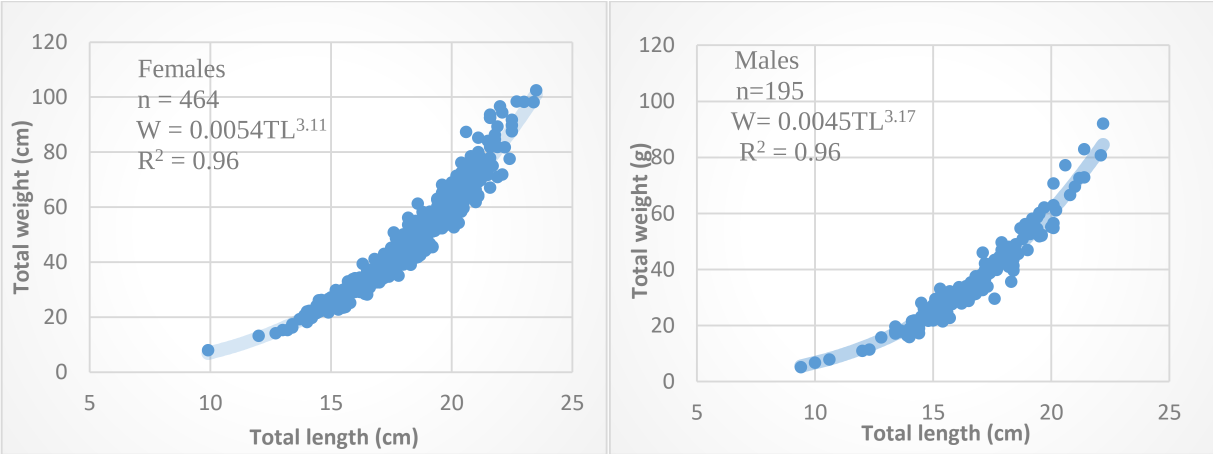


**Figure 3.** The length-weight relationships for females and males of *C. linguatula* from Saros Bay

A total of 659 individual otoliths were examined. Age was successfully determined in 477 (72.4%) of the otoliths, and the remaining 182 otoliths were rejected as there was no agreement between readers or because they were unreadable. The age distribution ranged from I to VI years, and the mean length at age (for females and males) are given in Table 1.

**Table 1.** Mean total lengths (TLs) together with the ages for females and males of *C. linguatula* from Saros Bay

| Age | N | Females<br>Mean Length ± S.E<br>(Min – Max) | N | Male<br>Mean Length ± S.E<br>(Min – Max) |
|---|---|---|---|---|
| 1 | 24 | 12.1 ± 0.61<br>9.9 – 12.5 | 19 | 12.6 ± 0.36<br>9.4 – 13.2 |
| 2 | 40 | 15.3 ± 0.10<br>14.0 – 16.2 | 51 | 15.0 ± 0.09<br>13.9 – 16.5 |
| 3 | 93 | 17.8 ± 0.07<br>16.5 – 19.5 | 32 | 16.6 ± 0.09<br>15.2 – 18.1 |
| 4 | 144 | 19.3 ± 0.06<br>17.5 – 20.1 | 7 | 18.0 ± 0.25<br>17.1 – 18.9 |
| 5 | 59 | 21.2 ± 0.07<br>20.0 – 23.0 | –<br>– | –<br>– |
| 6 | 8 | 22.7 ± 0.13<br>22.0 – 23.5 | –<br>– | –<br>– |
|  | 368 |  | 109 |  |

The von Bertalanffy growth parameters were computed as $L_\infty = 25.6$ cm, $k = 0.24$ year$^{-1}$, $t_0 = -1.64$ year for females and $L_\infty = 21.7$ cm, $k = 0.29$ year$^{-1}$, $t_0 = -1.96$ year for males; (Fig 4.).

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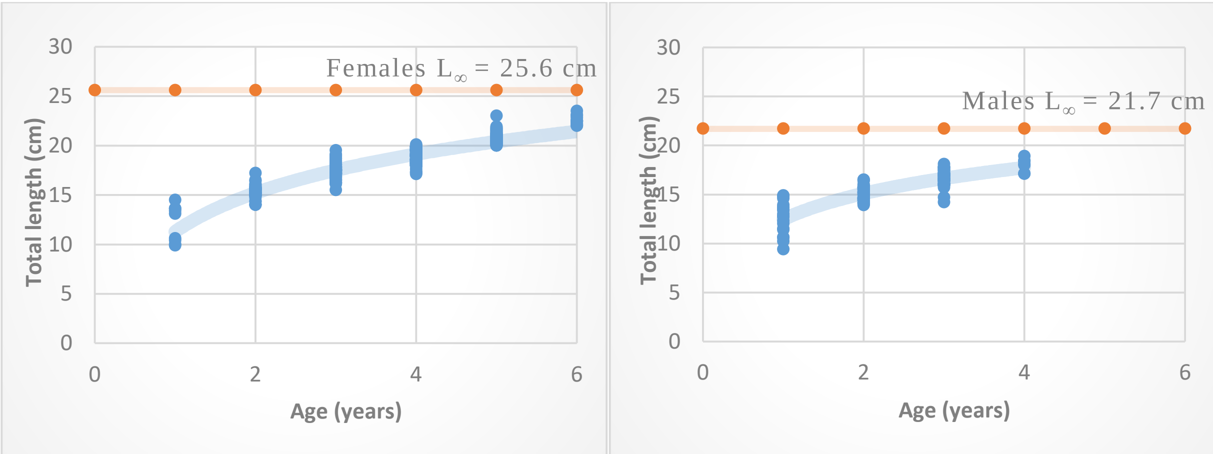


**Figure 4**. The von Bertalanffy growth curve for females and males of *C. linguatula* from Saros Bay

**DISCUSSION**

The possible reasons of differences in length-weight relationships could be attributed to area, gonad maturity, habitat, degree of stomach fullness, season, length range, sex, health, preservation techniques (Baganel and Tesch, 1978), number of specimens analyzed, area/season effects, and sampling duration (Moutopoulos and Stergiou, 2002), different fishing gear used (Kapiris and Klaoudaos, 2011) and size selectivity of the sampling gear (İşmen et al., 2007). Earlier studies on length-weight relationships of *C. linguatula* are summarized in Table 2.

**Table 2.** Earlier studies on length-weight relationships of *C. linguatula*.

| References | Locality | Sex | N | $L_{min}$ | $L_{max}$ | a | b | $r^2$ |
|---|---|---|---|---|---|---|---|---|
| Petrakis and Stergiou (1995) | Greek waters | Σ | 22 | 12.0 | 23.1 | 0.0086 | 2.97 | 0.98 |
| Moutopoulos and Stergiou (2002) | Aegean Sea, Greece | Σ | 19 | 10.3 | 17.5 | 0.0576 | 2.29 | 0.54 |
| Borges et al. (2003) | Algarve, Southern Portugal | Σ | 125 | 9.2 | 23.2 | 0.0120 | 2.78 | 0.92 |
| Çakır et al. (2005) | Edremit Bay, Turkey | Σ | 1096 | 6.9 | 22.2 | 0.0030 | 3.24 | 0.98 |
| | | ♀ | 481 | 6.9 | 21.4 | 0.0030 | 3.28 | 0.99 |
| | | ♂ | 615 | 6.9 | 22.2 | 0.0040 | 3.21 | 0.97 |
| Bayhan et al. (2009) | Izmir Bay, Turkey | Σ | 1429 | 6.8 | 23.2 | 0.0032 | 3.27 | 0.99 |
| | | ♀ | 298 | 7.7 | 21.7 | 0.0028 | 3.30 | 0.99 |
| | | ♂ | 398 | 6.8 | 22.0 | 0.0031 | 3.26 | 0.99 |
| Özekinci et al. (2009) | Saros Bay, Turkey | Σ | 1755 | 8.2 | 23.5 | 0.0061 | 3.07 | 0.96 |
| This study | Saros Bay, Turkey | ♀ | 464 | 9.9 | 23.5 | 0.0054 | 3.11 | 0.96 |
| | | ♂ | 195 | 9.4 | 22.2 | 0.0045 | 3.17 | 0.96 |

N: Sample size; Min: minimum; Max: maximum; *a* and *b*: intercept and slope of length- weight relationships; $r^2$ is the coefficient of determination;
Σ: All samples; ♀: Females; ♂: Males;

The age ranges in this study were I-VI years. Vassilopoulou and Papaconstantinou (1994) and Teixeira et al., (2010) report the age ranges of 0-VII for the Aegean Sea, and I-VII for the Portuguese Coast, respectively. In the present study, the absence of 0-group individuals could be probably a function of gear selectivity (Koç et al., 2007). The mean lengths at ages for females and males of *C. linguatula* presented by various authors are shown in Table 3.

**Table 3.** The mean lengths at ages for females and males of *C. linguatula* presented by various authors.

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| References | Locality | Sex | Age Group (years) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | I | II | III | IV | V | VI | VII |
| Vassilopoulou and Papaconstantinou (1994) | Aegean Sea, Greece | ♀ | 8.1 | 11.2 | 14.5 | 16.9 | 19.3 | 21.0 | 22.4 | 23.4 |
| | | ♂ | 7.7 | 11.6 | 13.9 | 16.3 | 18.7 | 20.3 | - | - |
| Çakır et al. (2005) | Edremit Bay, Turkey | Σ | - | 12.6 | 16.2 | 20.3 | 21.5 | - | - | - |
| Bayhan et al. (2009) | Izmir Bay, Turkey | Σ | - | 10.4 | 14.3 | 18.0 | 19.9 | - | - | - |
| This study | Saros Bay, Turkey | ♀ | - | 12.1 | 15.3 | 17.8 | 19.3 | 21.2 | 22.7 | - |
| | | ♂ | - | 12.6 | 15.0 | 16.6 | 18.0 | - | - | - |

Σ: All samples; ♀: Females; ♂: Males

The present results indicate that females have a longer life span than males, as also reported by Vassilopoulou and Papaconstantinou (1994) (Table 3). The greater and faster growth in females than in males is a common feature in many pleuronectiforms (Lozan, 1992; Başaran et al., 2008; Cengiz et al., 2013a). This may be related to differences in metabolism between females and males, such as differences in oxygen consumption (Pauly, 1994a; 1994b), differences in the level of surplus energy between reproduction and somatic growth (Rijnsdorp and Ibelings, 1989) and differential food ingestion (Lozan, 1992).

In general, the probable reasons of differences in length at age and growth parameters between different areas could be related to a combination of sampling (sampling gear used, sample size and length ranges of samples examined), geographical differences, ageing methodology used (Monterio et al., 2006, Cengiz et al., 2013b), incorrect age interpretation (Matic-Skoko et al., 2007), differences in length at first maturity (Champagnat, 1983), diet and water temperature (Santic et al., 2002). The age distribution and growth of the studied species should be effected by fishery compared to other areas, depending on the spatial extention of the population. For comparison of growth parameters and growth performances indices, Table 4 summarizes results obtained from the present and previous studies on *C. linguatula*.

**Table 4.** Results of growth parameters and growth performance indices obtained from previous studies for *C. linguatula*.

| References | Locality | Sex | $L_\infty$ (cm) | k (year$^{-1}$) | $t_0$ (year) |
|---|---|---|---|---|---|
| Vassilopoulou and Papaconstantinou (1994) | Aegean Sea, Greece | ♀ | 25.9 | 0.26 | -0.42 |
| | | ♂ | 22.9 | 0.30 | -0.46 |
| Garcia-Rodriquez and Esteban (2000) | Iberian Mediterranean | ♀ | 33.0 | 0.25 | -0.04 |
| | | ♂ | 30.0 | 0.25 | -0.16 |
| Çakır et al. (2005) | Edremit Bay, Turkey | Σ | 25.3 | 0.25 | -1.68 |
| Ulutürk (2007) | Izmir Bay, Turkey | Σ | 27.4 | 0.21 | -1.64 |
| Bayhan et al. (2009) | Izmir Bay, Turkey | Σ | 26.2 | 0.30 | -0.62 |
| Teixeira et al. (2010) | Portuguese coast | ♀ | 30.2 | 0.19 | -3.40 |
| | | ♂ | 30.8 | 0.15 | -4.40 |
| This study | Saros Bay, Turkey | ♀ | 25.6 | 0.24 | -1.64 |
| | | ♂ | 21.7 | 0.29 | -1.96 |

Σ: All samples; ♀: Females; ♂: Males

$L_\infty$ values from two western Mediterranean areas are remarkably higher compared to all other eastern Mediterranean values, which are fairly similar. This may be due to the fact that the eastern Mediterranean is one of the most oligotrophic areas of the world (Azov, 1986). The *t*-test showed no significant differences in the growth performance indices between the present and previous studies (P > 0.05).

As a result, though there are some differences between the results reported by various researchers concerning the length-weight relationship and growth parameters of *Citharus linguatula*, our findings are generally in line with the other studies. Possible causes of the small differences in life-history parameters may be related to differences in environmental conditions and/or sampling strategy and the information will contribute to fisheries scientists in future studies of *C. linguatula*.

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