PRELIMINARY ASSESSMENT AND MITIGATING BY-CATCH OF EUROPEAN EEL IN A LONGLINE FISHERY IN BARDAWILL LAGOON, NORTH SINAI, EGYPT

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SUMMARY

European eel, Anguilla anguilla is listed as critically endangered by the International Union for Conservation of Nature. Demersal longlines are the main fishing method used to target this species in Bardawill lagoon. Three trials were conducted to investigate catches (catch composition, catch rates, by-catch and CPUE) using hooks size No. 13, 12 and 11 from November, 2017 to January, 2018. Nine fishing trips (9 one trip days) were carried out. Within each trip, two longlines per hook size, each one involving 350 hooks, were set during sunset. After one hour, the longlines were pulled out. A total of nine species were recorded in all treatments, 1282 fish were caught, weighing a total of 194.71 kg. Catch rates (number of fish per 100 hooks) ranged between 3.3 and 9.5, with a decrease in catch rate with increasing hook size. Mean TL of eel were significantly different among the three hooks. Eels caught on small hooks (No. 13 and 12) had a significantly smaller mean TL (mean TL 43.9 cm) compared to eel caught on large hooks (No. 11, mean TL 45.1 cm). Catch rates of small eel (mean TL 39.5 cm) was highest in November followed by December and January. The highest CPUE was achieved when small hooks (No. 13) were used compared to large hooks (No. 11). To reduce capture of small eels (mean TL 45.1 cm) fishermen in the demersal longline fishery in Bardawill Lagoon are encouraged to use hooks size No. 11 with a bend width ≥12.7 mm. Furthermore, future management measures should introduce minimum landing sizes for European eel to avoid capture of small eel (mean TL 45.1) and thereby reduce fishing mortality preventing stock degradation of these economic valuable species.

Keywords: Demersal longline fisheries, Anguilla anguilla, hook size, Bardawill lagoon

INTRODUCTION

The demersal longlines became widely used in Bardawill lagoon targeting European eel (Anguilla anguilla, Linnaeus 1758) alongside other species, that may be below the mature sizes. The European eel, spend part of its life in Bardawill lagoon, Eastern Mediterranean as a visitor in its complex life cycle which reproduces in the open ocean. European eel has been listed as critically endangered by the International Union for Conservation of Nature (Jacoby and Gollock, 2014) and in Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora to control its trade (CITES, 2014). Stocks of this species obviously declined and being no longer within biologically safe limits, over-exploitation one of the reasons for that (FAO and ICES, 2007; ICES, 2012 and 2014). In recent years, European eels were heavily exploited by hook and line fishermen in Bardawill lagoon. Globally, efforts must therefore be made to save this important species where that complex life cycle, the late reproduction and long life span of eels render them vulnerable to over-exploitation. Globally, Anguillan eel have sharp declines to less than 10% of their population levels compared to the 1970s, in recent decades (Jacoby et al., 2015), and stock of European eels remains critical (ICES, 2015). Aalto et al., 2016 concluded that, research will have to focus on the south and east Mediterranean lagoons for studies on habitat loss, catches and effort of the European eel (hereinafter called ‘eel’). Our noticing of longline fishermen indicate that juvenile eels (below 50 cm TL) constitute a high percentage in current catches using mostly hooks size No. 12 and 13. However, according to fishermen larger hooks (e.g. No 11) were not suitable for catching eel. So, a range of mitigation strategies should be applied to avoid catch of undersized eel by such fishing gear, where there is no legislation limiting the mean legal length (MLS). Thus, the current study aimed to provide a basis for determining the most suitable hooks size to reduce the capture of undersized eel in Bardawill lagoon.

MATERIALS AND METHODS

The study was carried out in Bardawill lagoon (Figure 1). The lagoon is a natural depression and covers an area of ≈ 650 km² with a depth of 0.3 to 3 m (EEAA, 2008). It is located in the eastern Mediterranean Sea northern part of Sinai Peninsula, Egypt.

Figure 1. Map of Bardawill lagoon
Demersal longlines operations targeting eel in the lagoon are restricted to the period between November and January. This study is based upon comparative catch data obtained from 27 fishing sets of different hooks sizes carried out in the demersal longlines fishery in Bardawill lagoon. The study was conducted between November 2017 and January 2018 (the traditional fishing season for this gear). Fishers operating in the lagoon use “J” style hooks size No. 13. After consultation of fishers, we used three J-style hooks for this study: Nos. 13 (with a bend width of 9.9 mm), 12 (with a bend width of 11.5 mm) and 11 (with a bend width of 12.7 mm) as shown in (Figure 2). Catches were iced, labeled and transported to the laboratory for processing.

In the laboratory, catches were sorted by species and total length (TL) measured to the nearest 0.1 cm and weighed. Eel were classified into two groups: target (adult, ≥ 50 cm TL) and undersized (juvenile < 50 cm TL) to examine differences in catch rates by hook size. Length at first capture and minimum legal size were determined according to FAO database, annual reports of ICES and previous results (e.g. Eels (females) usually mature at sizes > 45 cm (Tesch, 2003; and Durif et al., 2005). The 50 cm body length corresponds to the legal minimum capture size of eel in Germany (Weltersbach et al., 2018), 60 cm in Sweden, 50 cm in Poland (ICES, 2014), and 55 cm in Estonia (Bernotas et al., 2016 and Silm et al., 2017). Also, Seabream (Lm30 ≈ 21.6 cm Lt, Salem, 2011) and Sea bass (Lm30 ≈ 31.6 cm Lt, Ameran et al. 2008), which below Lm30 were considered as undersized to allow spawning at least once before capture to sustain their stocks. All the rest of the catches were considered as a by-catch.

Length at first capture (Lc30) value was determined for eel using the probability of capture from the pooled length frequency distribution curve. The catch data were standardized pooling all monthly fishing trips (2100 hooks). The mean Catch Per Unit Effort (CPUE) was calculated dividing the total weight (kg) by the pooled monthly fishing trips (2100 hooks).

Differences in catch rates, sizes and mean CPUE of eel caught on different hook sizes (Each one n = 6300 hooks) were assessed using ANOVA.

RESULTS

A total of nine species were recorded in all treatments, 1282 fish were caught, weighting a total of 194.71 kg (Table 1). Catch diversity decreased with increasing hook size. Decreasing hook size led to increase fish catches; 71.54, 66.53, and 56.64 Kg with hooks size Nos. 13, 12 and 11, respectively. Catches were dominated by eel accounting for 81.7 % by number and 83.3 % by weight, followed by a few species as Seabream (Sparus aurata) and Sea bass (Dicentrarchus labrax). There were significant differences (p < 0.05) in numbers of eel caught by hook size. 46.4% of eels caught on small hooks (No. 13) versus 16.4% caught on large hooks (No. 11). Average total landing for eel caught on hook size No. 11 was significantly different than those caught by Nos. 13 and 12 hooks. Also, there were significant differences (p < 0.05) in mean TL for eel between hook size No. 11 and others and non-significant between Nos. 13 and 12. Means of TL were 43.9, 45.1 and 51.2 cm for each combination of hook size Nos. 13, 12 and 11, respectively. Sand flathead fish (Platycephalus bassensis) appeared in the catch in marked quantities as presented by 5.7% of total catches.

Mean catch rates (number of fish per 100 hooks) were 9.5, 7.5 and 3.3% for hooks size Nos. 13, 12 and 11, respectively. Mean catch rates were significantly (p < 0.05) influenced by hook sizes.

Length-frequency distributions of eel for each hook size followed normal distribution as shown in Figure 3. The distributions are overlapping (no significant of differences in catch frequency) between the smallest hooks (Nos. 13 and 12) and catch frequency was significant (p < 0.1) decreases with the largest hook (No. 11). Lengths of eel ranged from 32 to 83 cm (Lc) for all hooks. The length distributions by hooks Nos. 13, 12 and 11 were 32 - 72.5, 32.1 - 74.5 and 33.5 - 83 cm, respectively.
Results indicated that, catch of undersized individuals and non-targeted species were significant \((p < 0.05)\) and affected by hooks size. The highest catch of undersized eel (489 out of 599 individuals by numbers and 60% by weight of total catches) was recorded with the smallest hook size (No. 13), 356 out of 474 and 108 out of 209 individuals by numbers as undersized eel and 50.8 and 23.2% by weight of total catches was recorded for hooks Nos. 12 and 11, respectively (Table 2 and Fig.4).

Table 2. Target and undersized of species (number and weight) for three hooks sizes

<table>
<thead>
<tr>
<th>Species</th>
<th>Hook size 13</th>
<th>Hook size 12</th>
<th>Hook size 11</th>
<th>Total no</th>
<th>Total TW (Kg)</th>
</tr>
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<tr>
<td></td>
<td>no</td>
<td>L(cm)</td>
<td>S.D</td>
<td>TW (Kg)</td>
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<tr>
<td>Anguillidae</td>
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<td>43.9</td>
<td>7.58</td>
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<td>Sparidae</td>
<td>14</td>
<td>20.0</td>
<td>1.58</td>
<td>1.664</td>
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</tr>
<tr>
<td>Moronidae</td>
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<td>0.90</td>
<td>0.148</td>
<td>2</td>
</tr>
<tr>
<td>Dicentrarchus labrax</td>
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<td>23.6</td>
<td>4.46</td>
<td>3.266</td>
<td>17</td>
</tr>
<tr>
<td>Diplodus sargus</td>
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<td>27.3</td>
<td>1.51</td>
<td>1.192</td>
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<tr>
<td>Platycephalidae</td>
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</tr>
<tr>
<td>Dicentrarchus punctatus</td>
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<tr>
<td>Platycephalus bassensis</td>
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<td>13.2</td>
<td>2.04</td>
<td>0.395</td>
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<tr>
<td>Terapon puta</td>
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<td>2.25</td>
<td>0.135</td>
<td>1</td>
<td>31.2</td>
</tr>
<tr>
<td>Sciaenidae</td>
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<td>3.146</td>
<td>3</td>
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</table>

Figure 3. Length frequency distribution of eels caught with various hooks sizes

![Figure 3. Length frequency distribution of eels caught with various hooks sizes](image-url)
Monthly, catch rates of undersized eel varied considerably. Catches of undersized eel (mean TL 39.5 cm) accounted for 80% (numbers) and 52.5% (weight) of the total catch in November followed by December, 72.9 and 44.9% and January 67.2 and 40% respectively (Table 3).

There were overlapping lengths at first capture (Lc50) of eel between hooks Nos. 13 and 12 for the smaller lengths (undersized), but higher lengths as hook size increased indicating that eel size significantly increased with increasing hook size (Figure 5). The Lc50 was 42, 42.1 and 50 cm for eel captured with Nos. 13, 12 and 11-hooks, respectively.

### Table 3. Monthly catches of adult and undersized eel (number and weight) for different hooks sizes.

<table>
<thead>
<tr>
<th></th>
<th>Hook size no</th>
<th>TW (Kg)</th>
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<th>no TW (Kg)</th>
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<td></td>
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<td>29.2</td>
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<td></td>
<td></td>
</tr>
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<td></td>
<td>12</td>
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<td>51</td>
<td>13.708</td>
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<td></td>
<td></td>
<td>37.2</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>11</td>
<td>39</td>
<td>17.013</td>
<td>40</td>
<td>18.445</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75.8</td>
<td></td>
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</tbody>
</table>

### Figure 4. Undersize of eel in hooks size

### Figure 5. The length at first capture (Lc50) of eel for different hooks sizes.

The highest CPUE (23.85 Kg/boat/fishing day) was achieved by hook size No. 13, while the lowest CPUE (18.88 Kg/boat/fishing day) was achieved by hook size No. 11 and catches by hook size No. 12 were 22.18 Kg/boat/fishing day respectively (Figure 6).
DISCUSSION

This study provides a preliminary assessment of the impact of different hook sizes on the catch of European eel, since there is no legislation limiting hook and line gear, which needs to be taken into account for future fishing operations in Bardawill lagoon. There is a lack of information on line gear, catch composition; catch rates and factors which affect them. The total weight of eel in the use of small hooks was significantly higher compared to large hooks. Hook size affected not only the numbers and weights of individuals caught, but also the diversity of the catch as a whole. Bream and terapon fishes were captured with hooks No. 13 and 12 only. The numbers and species composition of fish caught can be influenced by a number of variables such as hook size and design (Erzini et al., 1998) where they found that, smaller hooks (No. 15 and 13) caught more breams (Sparidae) than larger hooks (No. 11). Landings in weight and the diversity of species caught were lower with large hooks (No. 11). Decreasing the hook size led to higher catch rates of most species. Results indicated significant differences in target eel size and catch rate (number and weight) between the commonly used hook size (No. 13) and the other two hook sizes (Nos. 11 and 12) used in this study. This result was confirmed by previous studies as Otway and Craig (1993), Alos et al. (2008) and Mongeon et al. (2013) which found an inverse relationship between catch rates and hook size where generally smaller hooks gave higher catch rates than larger ones. In a study conducted by Patterson et al. (2012) on the size of circle hooks, they found that, increasing hook size led to increased capture size and greatly diminished the diversity of the catch. This result differed from Ralston (1982); Bertrand, (1988), Fernö and Olsen (1994) which noted that different hook sizes did not notably modify catches.

Results showed apparent lack of differences in size distribution between small hooks and little evidence with the large hook while there were negatively relation among hooks size and the catch rates as the greater proportion of catch was achieved smaller hooks. Therefore, the hooks size could impact fishing effort and change the dynamics of eel. These results were confirmed by Erzini et al., 1999 in a study on different hook sizes, where they found the highest catch rates were obtained with the smallest hook. Catch rates are influenced by a number of variables in fisheries as hook size (Piovano et al., 2010). Decline in catch rate with increasing hook size for all fishes was observed by Garner et al. (2014).

In spite of, peak frequency sizes of eel that has been caught in the all hooks were small (35-45 cm), increased of hook size led to catch the large fishes while reducing the number of smaller fish. Though the general overlapping of length frequency curves of different hook sizes, a size 11 hook offers the best result to reduce the young eels in fishery. The size of the hook affects the structure of the size and distribution of the length of the catch (Punt et al., 1996 and Bayse and Kerstetter, 2010). It is not surprising that the catch size-frequency distributions of the different-sized hooks were often overlapping (Erzini et al., 1996; 1997 and 1999).

By-catch is critical component of fisheries management, as catch of undersized fishes and non-targeted species represented a global fisheries problem (Davies et al., 2009). The present work revealed that landings of by-catch species were much higher for the small size hooks than for the large size hook. By-catch is high (>100% of targeted landings), moderate and low with hooks size No. 13, 12 and 11.
respectively. This results that is consistent with previous research as Bacheler and Buchel, 2004. Hooks size was effective strategy to mitigate by-catch in demersal longline fishery especially of the European eels. By-catch in 11 and 12-hook sizes are a contributing factor to the decline of threatened species as eels, basses and breams fishes. By-catch in 11-hook size is moderate (23.2% of total landings) and does not include endangered species as breams fish. The size of the hook may be more important to impact on by-catch and small size of hooks that cause heavy fishing pressure on juveniles (Durai et al., 2011 and FAO, 2014). Selectivity of the hooks is due to the choice of the hook itself in relation to the size of the fish. Small-sized fish can swallow a hook no bigger than a certain size. While large fish escape from that small size of hooks where the small hooks cannot hooked the large fishes. Portion loss has already been observed of the large fishes during the fishing operation by the small hooks. Therefore, by changing the size of the hook can control the side catch of small-sized fish satisfactorily. The results show that most of the catch was under 50 cm in length, more than 73% under the legal size of all eels catch. The results suggest that could be decreased the smaller sizes of eels by hook size regulations, where fishers can significantly decrease the catch of small eels by using hook size No. 11 instead of Hook No. 13, however, it is difficult to eliminate the catching of young eels. This result corresponds with the findings of Campbell et al. (2014). In a study by Weltersbach et al. (2018), showed that anglers can reduce catch of small eels by appropriate hook choice. The increase of by-catch during November was due to the large diversity of stocks during that period and the increase in feeding activity compared to other months, e.g. Bream fish migrate in the latter half of November and the feeding activity of Terapon fish is reduced in December and January.

Although hooks size Nos. 13 and 12 could be regulate the lengths at first capture ($L_{50}$) of target sizes of eels, the overlapping of the small lengths indicate that hooks would not mitigate undersized catch. Large hook No. 11 may be the most appropriate hook to use, Increasing the hook size used in a fishery can exclude undersized fish (Alos et al. 2008 and Campbell et al., 2014).

The results showed a significant increase in CPUE using the small hook. Similar results were obtained by Halliday, 2002. The smaller hook is the most widely used by fishermen and provides the best results for them in the short term, but it may be destructive to eel stock and some other important species in the long term.

CONCLUSION

Study suggest that hooks size Nos. 13 and 12 regulations do not efficiently target sizes to achieve reductions in by-catch, the by-catch and juveniles were negligible in the catches of hook No. 11. In the case of hooks Nos.13 and 12 by-catch and juveniles accounted dangerous numbers. To avoid catching non-target species or to reduce juveniles, then the largest hook (No. 11) should be the most preferable hook choice. Also, Eels of less than 40 cm should be released if caught by fishers. Fishing should be prevented by this gear during November of each year due to the high by-catches in this period, especially of bream fish. These are important recommendations for sustainable development of demersal longline fisheries in Bardawill lagoon, Eastern Mediterranean Sea.

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REFERENCES


تم إدراج تعبير السمك الأوروبي (Anguilla anguilla) ضمن الأسماك المهددة بالانقراض من قبل الاتحاد الدولي للحفاظ على الطبيعة. الصيد بالخيوط البطيئة الطويلة (المدى) هو طريقة الصيد الرئيسية المستخدمة لاستهداف هذا النوع. أجرت ثلاث تجارب لتقييم المصيد (الأعداد، الأنواع، المصيد العرضي وانتاجه) وجد الصيد أرقام 13 و 12 و 11 من نوفمبر 2017 إلى يناير 2018. اشتملت الملاحظات على سعة رحلات الصيد (كانت الرحلة يومًا واحدًا). تم العمل بخطوات (أعلاهم) لكل حجم من الخيوط في كل رحلة، كل خطط منها 50 ملم دقيقًا. تم وضعها في الماء قبل غروب الشمس. بعد ساعة واحدة تقريبًا تم شراء الخيوط. تم تسجيل نسبа أنواع من الأسماك في جميع العمليات، تكون نحو 122 سمًا، مما يزن إجماليًا 14.7 كجم. تراوحت مساحة السواحل (عدد الأسماك لكل 100 متر) بين 3.2 و 9.5%، مع أنخفاض في معدل الصيد مع زيادة حجم الخيوط. ارتبط النتائج سلبًا سواءً عدلياً أو مترئساً بحجم الخيوط بشكل معنوي. لوحظ أن المصيد العرضي كان مرتفعاً مع الخيطان أرقام 13 و 12. الخيطان رقم 11 كان الأقل في المصيد العرضي والاقل ضرراً لصغار التعابين. تم تسجيل الحد الأصلي للصيد المعرضي في نوفمبر والاقل خلال يناير. لوحظ داخل الأطوال الصغيرة عند الطول لأول صيد مع الخيطان 12 و 13. تم تسجيل أعلى نسباً بحجم الخيوط رقم 13 في حين تم تحقيق أقل مساحة من الخيطان رقم 11. المصيد العرضي، لسما الصفار من تعبير البحر الأوروبي في مصائد الخيوط البطيئة تحتاج إلى النظر في تقييم الخيوط المستقبلي وحفظ الاتكاء للتدوير. تفسير النتائج إلى أن الخيطات رقم 13 و 12 لن يخلفاً من المصيد العرضي وحماية صغار الأسماك. قد يكون الخيطان الكبير رقم 11 هو الأكثر ملاءمة للاستخدام. تشير استراتيجيات التصفيح هذه للعلاقة في منع الصيد العرضي لمعظم الأنواع.


التقييم الأولي والتصفيح من المصيد العرضي للتعابين الأوروبي في مصيد الخيوط الطويلة منخفض البردويل, شمال سيناء, مصر
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كلية الاستدراخ المائي والصيد البحري, جامعة العريش