The status of Algeria's sea cucumbers and their illegal trade

Karim Mezali[1]* and Farah Slimane-Tamacha[1]

Abstract

In Algeria, sea cucumber fishing is mainly done by divers and gleaners who target all holothurian species along the coast, especially the ones found in shallow water. To better understand how this fishery is organised, a survey took place from August to September 2018. Face-to-face interviews with fishers (gleaners and divers), members of coastal communities and local traders were carried out to gather detailed information on the fishery. In addition, an online survey was developed to allow stakeholders to respond anonymously. Seventy-eight responses were received from fishers and middlemen who were very familiar with the fishing and trade. These responses were received from 14 different *wilayas* (administrative areas) spread along the Algerian coast. The *wilaya* of Tipaza was found to be the most active in the fishery, followed by Mostaganem, Jijel and Algiers. Sea cucumber processing methods, sales and prices are also discussed, as well as, given the rapid development of the sea cucumber fishery, the urgent need for its effective management.

Key words: Sea cucumber, survey, illegal fishing, Algerian coastal waters

Introduction

Sea cucumbers are in high demand in Asian markets, mainly as a dried product called beche-de-mer (Purcell et al. 2018). Overfishing of sea cucumbers in many tropical countries has led to the capture of new target species from the Mediterranean Sea and the northeast Atlantic Ocean, such as *Holothuria tubulosa, H. poli, H. sanctori, H. arguinensis* and *Parastichopus regalis* (Gonzalez-Wangüemert et al. 2016; Neghli and Mezali 2019). The sea cucumber fishery is a minor activity in Algeria. Basic information on this fishery – such as the number of stakeholders involved, volumes caught and traded, and natural stock estimates – is lacking.

In Algeria, the law allows the collection of sea cucumbers, but not for commercial purposes (Order of 16 July 2008). The export of sea cucumbers is, therefore, illegal, which explains why so little information on the fishery is available. Nevertheless, illegal exports began in 2013 (Neghli and Mezali 2019) and this occurred following a growing Chinese presence in the country, which started in the early 2000s. This non-native population, fond of seafood and with contacts in China, and the main market for processed sea cucumbers, generated a high local demand for sea cucumbers. In response, a fishery developed along the entire Algerian coast before any monitoring or management plan could be put in place. The objective of the study described here was to collect information on the state of exploitation (catches, sales and processing) of sea cucumbers over 14 Algerian coastal *wilayas*.

Methods – Study area and survey

Our study was spread over 14 coastal *wilayas* (administrative divisions) along the Algerian coast: Tlemcen, Ain Timouchent, Oran and Mostaganem in the west; Chlef, Tipaza, Algiers, Boumerdes and Tizi-Ouzou in the middle; and Bejaia, Jijel, Skikda, Annaba and El Taref in the east. Our survey took place between July and September 2018 through face-to-face interviews with people involved in the sea cucumber trade (local traders, fishers and coastal communities). During our survey, we faced two main difficulties: 1) the reluctance or categorical refusal of the majority of fishers to answer our questions, and 2) the non-cooperation of the middlemen involved in the processing and export of the final product (i.e. beche-de-mer). For these reasons, we also developed an online survey in Arabic, the most spoken language in Algeria, which allowed people to respond anonymously.[2] It included questions such as: "Do you have a preference for a specific species of sea cucumber?" Responses allowed us to determine the most targeted species of sea cucumbers.

Results

Characteristics of the sea cucumber fishery in Algeria

In shallow infralittoral areas, holothurians are most often collected by hand and by free diving on soft or hard substratum. When sea cucumbers are no longer available at these shallow

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[2] https://forms.gle/71VWkx9cQPBBQ9XT9

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depths, fishers use small motorised boats to collect them at greater depths, using direct techniques (scuba diving), and/or indirect methods such as collecting bycatch (starfish) from fishers using demersal gill nets. In Algeria, professional and amateur fishers have long used sea cucumbers as fishing bait (Francour 1997; Mezali 1998). During our survey, we noted that longline fishers tended to replace their fishing bait of small pelagic fishes (e.g. sardines, horse mackerels, *Sardinella* spp.) and cephalopods (mainly squid) with juvenile, or parts of adult, sea cucumbers, due to the rising prices of these small pelagic fishes and cephalopods. We also noted that anglers prefer to use sea cucumbers to catch Sparidae (mainly the sea bream *Sparus aurata*), which are much appreciated in Algerian restaurants.

Most targeted sea cucumber species and sizes

All local sea cucumber species are targeted. Out of 78 respondents, 30% declared a preference for *Holoturia poli*, 27% for *H. tubulosa*, 25% for *H. arguinensis* and 18% for *H. sanctori* (Fig. 1).

Holothuria poli and *H. tubulosa* (Fig. 3A) are the most abundant sea cucumbers in Algerian waters. *H. arguinenis* (Fig. 3B) is a species originating from the Atlantic Ocean but recently reported as occurring in Algerian coastal waters by Mezali and Thandar (2014). *H. arguinenis* is highly valued for its thick body wall. *H. sanctori* (Fig. 3C and D) releases, soon after capture, Cuvierian tubules, which are sticky white threads that function as a defence mechanism. Once ejected, these tubules instantaneously stick to anything (such as hands of a collector) (Flammang 2006). This may explain why it is the least preferred of the four main species.

All sizes of sea cucumbers are targeted: small and medium-sized individuals are used as fishing bait, while medium and large individuals are sold and processed into beche-de-mer.

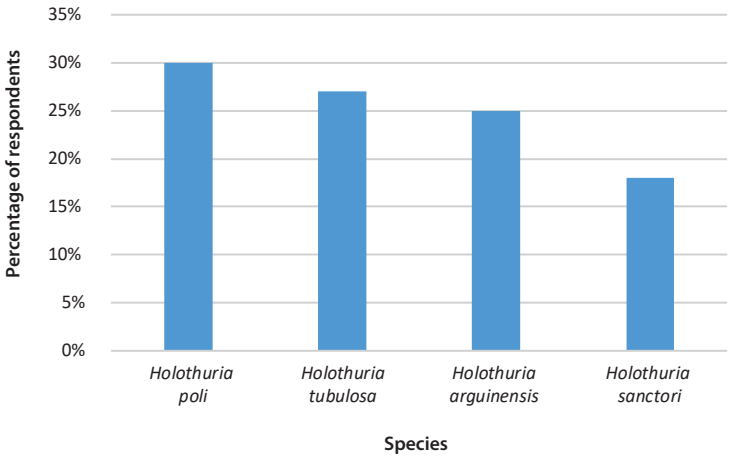

Figure 1. Fishers' preference for targeted species (in percentage).

Catch rates in the different wilayas

Sea cucumbers are fished all along the Algerian coast, but according to our survey, the best catch rates are obtained along the central coast (Tipaza and Algiers), followed by Jilel in the east and Chlef in the south (Fig. 2).

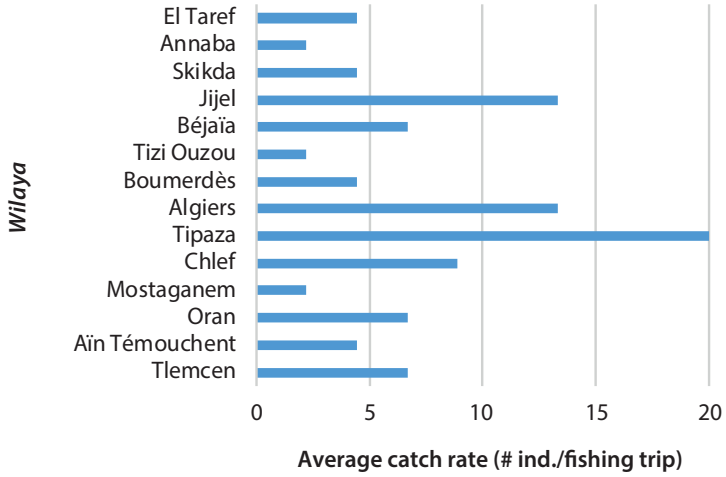

Figure 2. Catch rates (number of sea cucumbers collected per fishing trip) in each of the 14 surveyed wilayas.

Processing of sea cucumber catches in Algeria

Harvested sea cucumbers are usually kept in basins and stored in large quantities before their transformation into beche-de-mer by processors (Fig. 3).

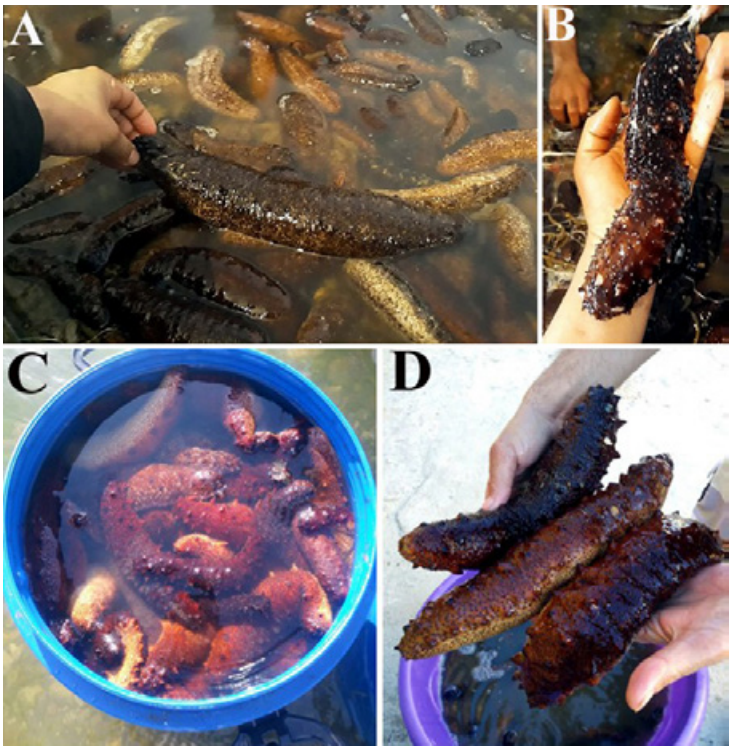

Figure 3. The processing of sea cucumbers: A) Individuals of different species kept alive in a basin. The processor is holding a specimen of *Holothuria tubulosa*; B) *H. sanctori*; C) Adult *H. arguinensis*; D) *H. arguinensis*. (Photos taken by a sea cucumber processor in Algiers, 2019)

According to our survey, 75% of harvested sea cucumbers are sold fresh to processors, but also to anglers as bait, and to Chinese nationals who reside in Algeria. Fishers are ignorant of the fate of these captured and sold animals. The remaining 25% is directly processed by fishers into beche-de-mer, using processing methods tailored to the targeted export market requirements. The most commonly used sea cucumber processing method involves: 1) evisceration, which can be done by the fishers themselves or by processors; 2) cooking in seawater for two hours; and 3) sun drying for six consecutive days or more. The duration of this last step depends on the season and geographical location. Some processors also salt and/or smoke sea cucumbers as a method of conserving them before drying and selling. These traditional methods of processing sea cucumber into beche-de-mer are the ones used in Algeria.

Sea cucumber trade and sale in Algeria

According to our survey, the selling price of sea cucumbers varies from one *wilaya* to another. Fresh animal prices vary from DZD[3] 200–700/kilo (EUR 1.5–5.9/kilo), while dried specimens (beche-de-mer) range in price from DZD 4800–12,000/kilo (EUR 36–90/kilo). Price also depends on demand for the product, its size, its availability and its destination.

Regulation of the sea cucumber fishery in Algeria

Algeria should be inspired by countries in the Pacific Islands region, where minimum sizes and seasonal closures of the fishery are commonly used measures to regulate the sea cucumber fishery (Kinch et al. 2008). In the hope of regulating sea cucumber exploitation, preventing overfishing and avoiding problems with customs (at the trade port), the administration in charge of the fisheries sector published two orders in the official newspaper of the Algerian Republic. The first (Order of 16 July 2008) to allow the collection of sea cucumbers by gleaning and by diving, but not to exploit them commercially because they are not listed in the National Plan of the Marine Biological Resources Regulation, which defines the minimum sizes allowed for commercially exploited resources (Neghli and Mezali 2019); and the second (Decree of 29 Ramadhan 1440, corresponding to 3 June 2019) to set a yearly 46-day closing period (from 1 August to 15 September) for sea cucumber fishing.

Unfortunately, the administration in charge of the fisheries sector does not collaborate with scientists and ignores the fisheries data they have already collected, as well as the scientific work (mainly on reproductive biology) they have already carried out and published in international journals (Neghli et al. 2013; Mezali and Soualili 2014; Mezali et al. 2014; Slimane-Tamacha et al. 2019). The 46-day closure, for example, only partially covers the breeding season of the various sea cucumber species present in Algerian waters.

Discussion

In Algeria, sea cucumber fishing is carried out mainly by hand in infralittoral waters, especially in shallow habitats of seagrass (*Posidonia oceanica*) meadows (Mezali 1998, 2004, 2008). This ease of access allows for intense fishing pressure in these areas, often leading to a local collapse of the most common sea cucumber populations. Fishers who collect sea cucumbers mostly sell them to processors or exporters. However, a survey conducted in the Algerian central region (Neghli and Mezali 2019) revealed the existence of a nascent network of fishers who process sea cucumbers into beche-de-mer by themselves. The depletion of sea cucumbers in shallow water areas of some Algerian *wilayas* has led to exploration of deeper zones. This spatial expansion has already been described for many tropical sea cucumber fisheries (e.g. Maldives, Philippines and Sri Lanka), where sea cucumbers catches first started manually near the coast before being done by diving or even trawling as shallow stocks diminished (Anderson et al. 2011).

According to the interviews we conducted with fishers in different Algerian *wilayas*, the sales price of fresh and dried sea cucumbers varies greatly from one *wilaya* to another and from one fisher to another. In some cases, it was difficult for us to know the exact selling price and destination of the final product due to the withholding of information by some traders. In general, it is estimated that, despite being the main actors in this illegal fishery, fishers are the ones within the market chain who benefit the least from the trade. The dry weight of the most properly processed sea cucumbers is 5–12% of their wet weight (Choo 2008). According to the information provided in our survey, the price of a dry processed sea cucumber is generally 17–24 times higher than the price of fresh (wet) sea cucumber. The majority of fishers do not master all of the steps of processing sea cucumbers into beche-de-mer. In fact, the only part of processing they master is evisceration, which brings very little added value to the product.

Furthermore, the lack of control over actual catches makes it difficult to develop analytical models to support the management of sea cucumber stocks. It is important to adopt a well-defined management plan to preserve this marine resource.

In order to manage sea cucumber resources in Algeria, several important measures must be taken. The development of guidelines for the management of natural stocks of sea cucumbers, and the monitoring of natural stock replenishment, are a priority. The management plan should also include the following measures:

1) Prohibit the collection of sea cucumbers during the breeding season of each species; the closing period should be extended (to June–September) or shifted (to July–August, rather than August–September) (Neghli et al. 2013; Mezali and Soualili 2014; Mezali et al. 2014; Slimane-Tamacha et al. 2019).

[3] DZD = Algerian dinars (DZD 100 = EUR 0.76 = USD 0.83, as of 12 February 2020)

2) Introduce a quota system.

3) Define minimum sizes for each species.

4) Create permanent protected areas in different *wilayas* along the Algerian coastline.

5) Issue fishing licenses to sea cucumber fishers.

6) Draft detailed datasheets, and make it mandatory for fishers, processors and traders to fill in and return these sheets to local fisheries authorities.

7) Train beche-de-mer processors to upgrade their skills.

8) Train all stakeholders who participate in the protection of coastal marine resources (e.g. coastguard officials, custom officers, fisheries directorate agents) in the proper identification of sea cucumber species exploited in Algeria, both in their live and dried forms, using illustrated guides and manuals.

9) Monitor all stages of the commercial sea cucumber trade in the country.

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Seasonal variation in food intake of *Holothuria* (*Roweothuria*) *poli* (Holothuroidea: Echinodermata) of Stidia in Mostaganem, Algeria

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Abstract

A study of the diet of *Holothuria poli* from the southwestern Mediterranean Sea (Stidia, Mostaganem) was carried out at a depth of 3 m during four seasons in order to gain an idea of the variation of the different trophic sources used and appreciated by this sea cucumber species. *H. poli* feeds on plants and animals, although diatoms constitute its most consumed food source. *H. poli* consumes large amounts of cyanophyceae in summer and algae in spring. The dead or living leaves of the seagrass *Posidonia* are also part of the diet of *H. poli*, but only in small proportions. In terms of animals consumed, foraminifera constitute the most important resource. A relatively large amount of sponge fragments, however, was observed in the digestive tract of *H. poli.* In addition, crustaceans are widely consumed in spring while nematodes and bivalve mollusc fragments are less consumed.

Key words: *Holothuria* (*R.*) *poli,* selective feeding, diet, seasonal variation, *Posidonia* meadow, Algeria

Introduction

Sea cucumbers play an important role in the recycling of organic matter within the food web of the *Posidonia oceanica* ecosystem (Zupo and Fresi 1984; Uthicke and Karez 1999; MacTavish et al. 2012). During feeding, these deposit-feeder organisms collect sediments with their tentacles to extract organic matter. The collection is done selectively with respect to the richness of organic matter particles (Mezali and Soualili 2013; Belbachir et al. 2014), which could be a strategy for ecological niche partitioning between different sea cucumber species. *Holothuria poli* (Delle Chiaje, 1824) is the most abundant holothurian in Algerian coastal waters (Mezali 2008; Belbachir 2018). The sediment ingested by this species consists mainly of inorganic matter (coral detritus, skeletons of marine organisms and benthos inorganic remains), detrital organic matter (marine plants, algae, decaying or dead animals) or microorganisms (bacteria, diatoms, protozoa and cyanophyceae) (Massin 1982; Moriarity 1982; Gao et al. 2014). Physical selectivity (size of sedimentary particles) and chemical selectivity (organic matter) of *H. poli* have been discussed for Algerian coastal areas (Mezali et al. 2003; Mezali and Soualili 2013; Belbachir et al. 2014) but data on the seasonal variations of its diet are lacking (Mezali et al. 2003). The aim of the present paper is to present a study of the diet of *H. poli* over the four seasons.

Methods

Ten individuals (20-cm long on average, contracted length) of *H. poli* and the uppermost millimeters of the sediment were collected during each of the four seasons (summer and autumn 2016, winter and spring 2017) at Stidia (35°49'N / 0°01'W) on the southwestern Algerian coast (Fig. 1). This site is located between two great commercial harbours (Mostaganem and Arzew), which are considered to be two potential pollution sources (Belbachir 2012). The seabed at Stidia is mainly composed of a succession of rocky and sandy substrata. The seagrass meadow (*Posidonia oceanica*) in the area is considered to be of type II (dense meadow, 400–700 plants/m^2), according to the classification by Giraud (1977). The fauna at the sampling site is mainly represented by echinoderms (*Ophioderma* sp. and *Paracentrotus lividus*), sponges, crustaceans (*Chthamalus* sp. and *Pachygrapsus* sp.), molluscs (*Littorina* spp. and *Patella* spp.) and fishes (*Coris* sp., *Diplodus* spp., *Serranus* spp. and *Sarpa* sp.) (Belbachir 2012). Flora is mainly represented by red algae (*Corallina* spp.), green algae (*Ulva* spp., *Caulerpa* spp.) and brown algae (*Padina* sp. and *Cystoseira* spp.) (Belbachir 2012). The invasive alga *Caulerpa racemosa* has also been present at Stidia since 2009 (Bachir Bouiadjra et al. 2010). This species has a hard body covered with a thin layer of sand (Mezali 2008), and inhabits detrital bottoms and *Posidonia* seagrass (Francour 1984; Mezali 2004).

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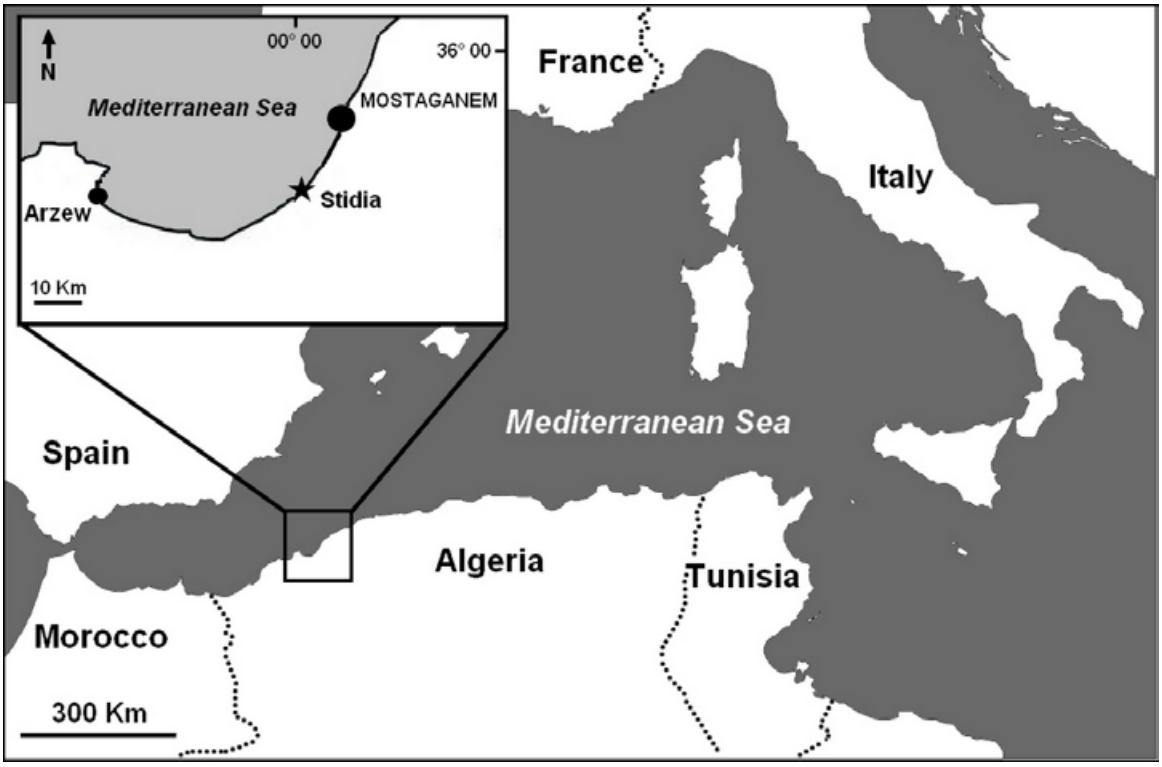

Figure 1. Geographical location of Stidia (star) where samples of *Holothuria poli* were collected.

Each specimen of *H. poli* and each sediment sample originating from the biotope collected were isolated in a plastic bag containing seawater for further processing. In the laboratory, each individual was dissected and the digestive tract content carefully collected for microscopic observations. The method developed by Jones (1968) and later modified by Nedelec (1982), was used for the digestive content analysis (see Belbachir and Mezali 2018). This method was also used for the sediment (holothurian biotope) analysis. Holothurian selectivity in food choice was studied by calculating the Ivlev electivity index $E' = (ri - pi) / (ri + pi)$, where ri is the ratio of a food item in the digestive content, and pi is the ratio of the same food item in the sediment (Ivlev 1961; Belbachir and Mezali 2018). Permutational multivariate analysis of variance (PERMANOVA) (Anderson 2001) was carried out using R v3.4.1 software (R Core Team 2017) to test the dissimilarity of the diet of *H. poli* during the different seasons.

Results

Seasonal variation of trophic resources

Summer

During summer, diatoms and cyanophycea are the most consumed vegetal components (30.7% and 14.7% of the diet, respectively) (Fig. 2). Macrophytes algae (mainly coralline) comprise 5.3% of the diet; dead and live leaves of *Posidonia* comprise 4.7% and 0. 7%, respectively (Fig. 2). The animal portion of the diet is mainly composed of foraminifera and sponge fragments (16.7% and 12.0%, respectively) (Fig. 2). Crustaceans, nematodes and bivalve mollusc fragments represent 5.3%, 5.3% and 2.0% of the diet, respectively (Fig. 2).

Autumn

During autumn, the vegetal component of the diet of *H. poli* is composed of diatoms (26.7%) and algae (10.0%), followed by cyanophycea (2.0%). The leaves of *Posidonia* (live or dead) are absent (Fig. 2). For the animal component of the diet, foraminifera is dominant (20.0%), whereas sponge fragments, crustaceans, nematodes and bivalve mollusc fragments are only present in small proportions (6.7%, 6.0%, 6.0% and 5.3%, respectively) (Fig. 2).

Winter

In winter, diatoms, cyanophycea and algae are the dominant vegetal sources at 31.1% 10.0% and 9.3%, respectively (Fig. 2). The dead and live leaves of *Posidonia* are present in low proportions (2.7% for the two items) (Fig. 2). Sponge fragments are highly represented in the gut during this coldest season of the year (17.9%) (Fig. 2). Animal sources, such as foraminifera, bivalve mollusc fragments, crustaceans and nematodes make up a small portion of the diet (6.6%; 4.1%, 4.0% and 1.3%, respectively) (Fig. 2).

Spring

In spring, diatoms are clearly dominant in the diet (38.0%), followed by algae (14.7%) (Fig. 2). Cyanophycea, live and dead *Posidonia* leaves represent 6.0%, 2.0% and 1.3% of the diet, respectively (Fig. 2). The animal component of the diet is mainly composed of foraminifera (14.0%) and crustaceans (13.3%) (Fig. 2). Sponges and nematodes represent only 2.0% and 1.3% of the diet, respectively, while bivalve mollusc fragments are not consumed during this time of year (Fig. 2).

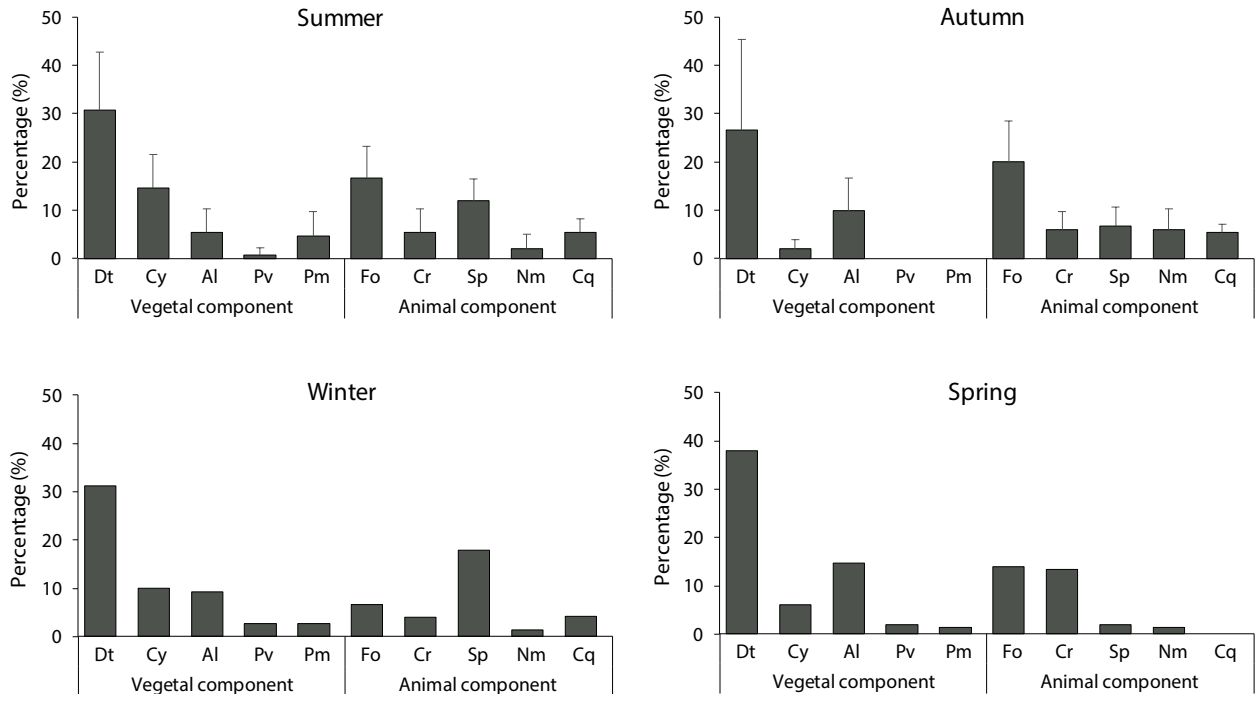

Figure 2. Seasonal variation (in percentage of diet components) of the different trophic sources of the diet of *Holothuria poli*. Dt: diatoms; Cy: cyanophyceae; Al: macrophytes algae; Pv: live Posidonia leaves; Pm: dead Posidonia leaves; Fo: foraminifera; Cr: crustaceans; Sp: sponge fragments; Nm: nematodes; Cq: bivalve mollusc fragments.

Selective behaviour towards food sources

PERMANOVA reveals a difference in diet between the four seasons ($P<0.001$). Although diatoms are dominant throughout the year, this food source is hardly selected in winter and spring ($E' = 0.1$) by *H. poli* and is avoided in summer and autumn ($E'<0$) (Fig. 3). The dead leaves of *Posidonia* are consumed during most seasons, and is sometimes the most preferred ($E' = 0.6$ in summer) (Fig. 3). Live *Posidonia* leaves are also consumed throughout the year, with the highest electivity index for this trophic source in spring ($E' = 0.4$) (Fig. 3). Algae and cyanophycea were also consumed, and the maximum electivity index for algae ($E' = 0.3$) was obtained in summer, while th maximum index for cyanophycea ($E' = 0.5$) was obtained in the spring (Fig. 3). Sponge fragments are a slightly preferred component of the diet, and the electivity index reaches its maximum values in summer ($E' = 0.2$, Fig. 3). Foraminifera show a negative electivity index throughout winter and spring ($E' = -0.3$ and -0.4, respectively), with the highest value obtained in summer and autumn ($E' = 0.1$, Fig. 3). Except during summer, *H. poli* preferentially consume crustaceans; the most important electivity index is obtained in autumn and spring ($E' = 0.3$ for both seasons) (Fig. 3). *H. poli* also preferentially consumes nematodes in autumn ($E' = 0.3$) and winter ($E' = 0.2$) (Fig. 3), although this food source is poorly represented in the gut contents.

Discussion

Food sources for *H. poli* are very diverse and their respective roles vary with seasons. The Ivlev electivity index reveals that diatoms are avoided in summer and autumn, although paradoxically, they still constitute the highest portion of the food content in the digestive tract of *H. poli,* which is probably due to their high availability in the environment during certain periods. In fact, nutrients originating from fertilisers used in agricultural areas adjacent to Stidia could be the reason for the high availability of diatoms. In spring, *H. poli* prefers photosynthetic organisms such as algae, diatoms and live *Posidonia oceanica* leaves. The high rates of diatoms and algae found in the digestive contents of holothurians was also reported by Sonnenholzner (2003) for *Holothuria theeli* from the Gulf of Guayaquil (Ecuador). The consumption of dead *Posidonia* leaves by detritus-feeders has been reported in the literature (e.g. Buia et al. 2000; Walker et al. 2001); this could have a significant impact on the primary production transfer from *Posidonia* plant. In fact, the litter biota mainly composed of dead leaves of *Posidonia* is an important source of organic matter for communities living in seagrass beds (Walker et al. 2001); it is even the main pathway for the organic matter transfer from *Posidonia oceanica* meadow (Cebrian et al. 1997). The consumption of live *Posidonia* leaves by *H. poli* is interesting as few marine animals consume them. In autumn, *H. poli* concentrates more on the animal component of its food sources, particularly on foraminifera and to a lesser degree on crustaceans, bivalve mollusc's fragments, and sponge fragments. Holothurians tend to change their food preferences according to seasons, and this is probably due to the availability of food items and their nutritional qualities. From our results, we think that *H. poli* exhibits a feeding plasticity in response to food items and their availability, which suggests that this sea cucumber is a generalist species.

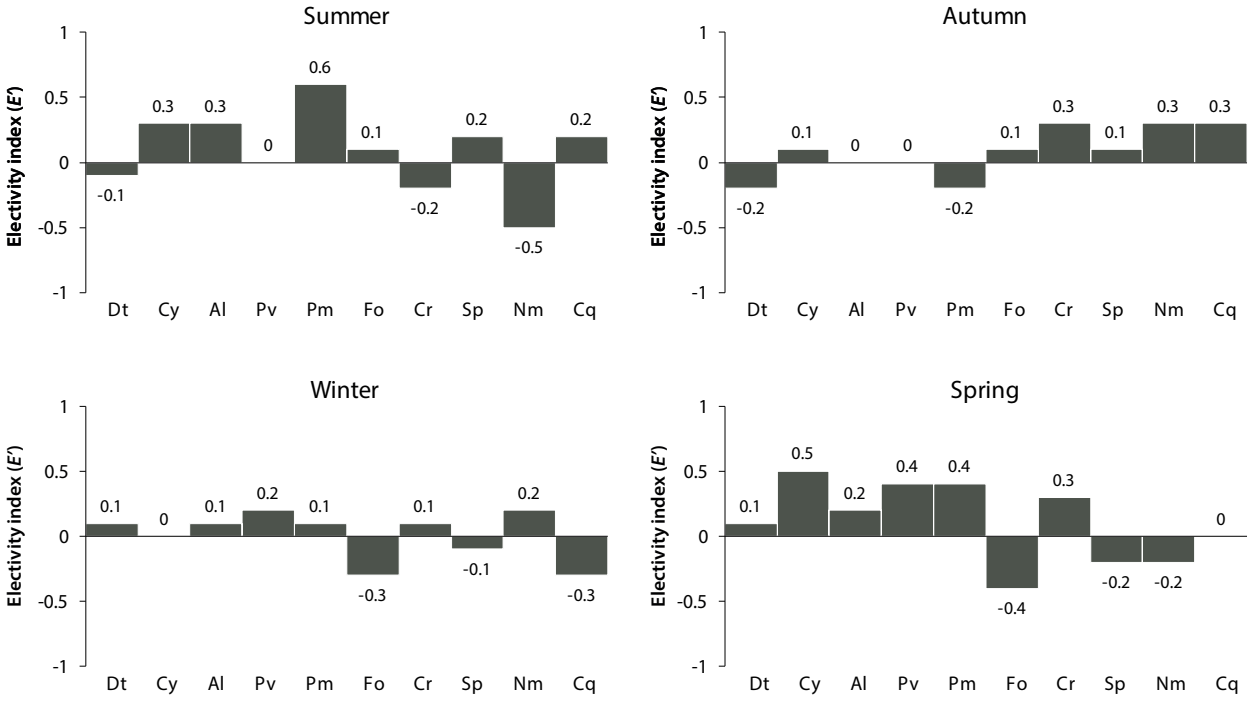

Figure 3. Ivlev electivity index indicating the preference or avoidance of a food source by H. (R.) poli. Dt: diatoms; Cy: cyanophyceae; Al: macrophytes algae; Pv: live Posidonia leaves; Pm: dead Posidonia leaves; Fo: foraminifera; Cr: crustaceans; Sp: sponge fragments; Nm: nematodes; Cq: bivalve mollusc fragments.

The components of the sediment are not all assimilated in the same way by the different sea cucumber species that inhabit the same place (Belbachir and Mezali 2018). In addition, sea cucumber species are distributed heterogeneously in various biotopes present at the same site (Mezali 2004). Consequently, even if all species ingest sediment, they can live in the same place as they are not really in competition with each other for food.

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