Turk. J. Fish.& Aquat. Sci. 20(1), 51-60
http://doi.org/10.4194/1303-2712-v20_1_05

PROOF
RESEARCH PAPER

Turkish Journal of FISHERIES and AQUATIC SCIENCES

Ecological Aspects of *Dormitator maculatus* Bloch, 1792 in the Alvarado Lagoon, Veracruz, Mexico

Jonathan Franco-López[1,*], Carlos Manuel Bedia-Sánchez[1], Edgar Peláez-Rodríguez[1], José Luis Viveros-Legorreta[1], Manuel Antolín Ortiz-Touzet[2], Horacio Vázquez-López[1]

[1]Laboratorio de Ecología, Facultad de Estudios Superiores Iztacala, UNAM. Av. de los Barrios No. 1, Los Reyes Iztacala, Tlalnepantla, Estado de México, México. C.P.54090.
[2]Laboratorio de Crustáceos, Facultad de Estudios Superiores Iztacala, UNAM. Av. de los Barrios No. 1, Los Reyes Iztacala, Tlalnepantla, Estado de México, México. C.P. 54090.

Article History
Received 04 May 2018
Accepted 07 January 2019
First Online 30 January 2019

Corresponding Author
Tel.:
E-mail: jonfrancol@yahoo.com

Keywords
Coastal ecosystem
Eleotridae
Fat sleeper
Food webs
Growth

Abstract

A study was carried out to assess the biological aspects of *Dormitator maculatus*, analyzing sex ratio, diet, and growth estimates based on the von Bertalanffy model. All organisms were captured with the help of 50 m. long cast fishing lines at ten sampling stations monitored between May 2015 and May 2017. 642 subjects were captured ranging between 3 to 14.7 cm total length for males, 3.9 to 15.9 cm for females. Sex ratio is 1:1 female:male, they consume nine different types of food, mainly *Ruppia marítima*, detritus, benthic algae and ostracods. The constants for the von Bertalanffy model for frequency analysis were, a Maximum Length (MaxL) of 22.37 cm for males, 22.71 and 22.93 cm or females, k= 0.20785 and 0.17199 for males, 0.20856 and 0.16749 for females. For scale analysis, the growth rate was MaxL =19.51, and k=0.26642. The grown rate estimate (Ø') ranging from 1.93 to 2.03 with the different adjustments. Currently, there is a reduction in population that may endanger its exploitation, affecting other species that feed from it, is recommended to increase the number of studies that aim at predicting the possible environmental impacts on productive use systems involving the ichthyofauna that inhabits the Alvarado lagoon.

Introduction

The state of Veracruz has 18 great coastal ecosystems along its coastline, which cover 1166 km^2 (Contreras-Espinosa, Castañeda, Barba & Pérez, 2002). During 2013, it ranked first as fish producer within the Gulf and Caribbean Sea region and fifth nationwide (SAGARPA, 2013)

The coastal ichthyofauna living in the Veracruz shoreline is comprised of multiple marine, estuarine and freshwater species (Franco, Chávez, Peláez & Bedia, 1996; Castro, Espinosa & Schmitter, 1999; Bedia & Franco, 2014), which represents a valuable resource for the fishermen living in over 40 municipalities engaged in fishing activities along the state coast and shoreline (Quiroga, Valdéz, Hernández, García & Guzmán, 2002). In the Alvarado Lagoon, some of them are solely used as finfish fishing for local and regional consumption, as bait, or for the full or partial consumption of the organisms.

Riverbank and coastal fishing are traditionally performed by communities with low quality of life where the organization of productive processes is supported by low technology and labor intensive methods, fishing is carried out intensively, which puts at risk most of the fishery resources, which are at their maximum exploitation limit (SAGARPA, 2005).

The species with the highest capture volumes in the area are for the Cichlidae family: *Mayaheros urophthalmus* (Günther, 1862), (Mojarra prieta) and *Petenia splendida* Günther, 1862, (Tenguayaca), whose exploitation takes place most of the year, however, fishery records include them as Mojarra. For the Sparidae family, *Archosargus probatocephalus* (Walbaum, 1792), (Sargo) is caught and it is not registered as in the state statistics, for the family Centropomidae, the species that are captured in the area are *Centropomus undecimalis* (Bloch, 1792), C. *pectinatus* Poey, 1860, C. *parallelus* Poey, 1860, and C. *poeyi* Chávez, 1961, are registered as Robalo and the statistics for the state of Veracruz were 6998 tonnes in 2017. For the Mugilidae family, the species that is captured mainly is *Mugil curema* Valenciennes, 1836, (Lebrancha) and the catch record in the state was 4738 tons in 2017. For the Eleotriade family, the species *Guavina guavina* Valenciennes, 1837 and *Gobiomorus dormitor* Lacepède, 1800, are captured most of the year, but there are no fishing records of these species, finally *Dormitator maculatus* (Bloch, 1792), known locally as "Naca", is captured in a very short period of time, of maximum 35 days and the estimated catch is 150 tons per year, exclusively from the gonads of the species, discarding the rest of the organism.

A characteristic of this species is its high physiological resilience, which allows it to survive in places with very low concentrations of dissolved oxygen, as is the case of the pastures and paddocks it inhabits; additionally, it is also capable of standing large fluctuations in salinity and temperature (Yánez-Arancibia & Díaz-González, 1976; Ancieta & Landa, 1977). Concerning its diet, it has been reported that this species feeds off detritus, algae and a minimum percentage of crustaceans and benthic invertebrates (Jonna & Weinheimer, 2003).

The distribution of *D. maculatus* has been reported all the way from New York, New Jersey and North Carolina to Brazil, including the Gulf of Mexico, Bahamas, Central America and the West Indies, in the Atlantic coastline, in shallow fresh and estuarine waters in rivers and coastal lagoons (Milstein & Thomas, 1976; Schwartz, Hogarth & Weinstein, 1982; Weinstein, 1985), and are mainly located at various microhabitats such as crabs or crayfish burrows, underwater vegetation and muddy areas (Winemiller & Ponwith, 1998; Taylor, 2001).

Several papers have been written in connection with the Alvarado Lagoon and the various biological components that inhabit it; regarding fish, we can mention the papers of Reséndez (1973); Flores and Méndez, (1982); Franco, Peraza and Chávez, (1992); Franco, Chávez, Peláez and Bedia (1996); Barrera, Franco, Zamudio and Martínez (2002); Chávez, Peterson, Brown, Morales and Franco (2005); Peláez, Franco, Matamoros, Chávez, and Brown-Peterson (2005); Salgado, Aguilar, Cabañas, Soto & Mendoza (2005); Zarza, Berruecos-Villalobos, Vásquez-Peláez and Álvarez-Torre (2006); Abarca-Arenas, Franco-López, Peterson, Brown-Peterson and Valero-Pacheco (2007); Carbajal *et al.,* (2009); Abarca, Cruz, Franco, González and Silva (2012); Franco *et al.,* (2014); Franco *et al.,* (2017), who address several aspects of this taxon, including early development stages, life and reproductive cycles, as well as food webs and community interactions. *D. maculatus* is mentioned in some of these papers, both as a community element or as part of food webs; however, only the paper of Montoya, Osorio, Chavez and Franco (2004), addresses issues on the helminth parasitism that usually affects this species and which is acknowledged as a vector for the transmission of the parasite to other species of the lagoon system.

The economic importance of this species is based on the extraction and commercialization of the gonad or "spawn" during the period of maturation and spawning (October-November). For the decade of the 90's, the price paid to the fisherman per kg. of gonad was $ 10.0 pesos (3.3 USD), from the local fishing registers, where an extraction volume of 210 tons was registered, for 2015, the local fishing offices no longer existed and based on the data provided by the fishermen and the landing sites, the price of the gonad of this species was $100.00 per kg., (5.5 USD). The above is worrisome, because it affects one of the vulnerable parts of the population such as mature females, and extraction and protection regulations for this species do not exist. The absence of information on fishery statistics, sizes and other biological aspects of this species in the study area make it difficult to carry out a complete analysis of the population dynamics, since there is no previous or continuous information on catches by fishing season or the extraction volumes. The present work was developed in order to provide information on the knowledge, both biological and ecological aspects of *D. maculatus* in the Alvarado Lagoon, such as their diet, sex ratio and growth, which may be useful in the definition of sustainable fishing management and use strategies.

Considering that this species is important for the economy of the inhabitants of the Alvarado Lagoon area, it is important to further improve our knowledge and understanding, both of its biological aspects and of the environmental impact on the dynamics of this system, in order to define sustainable management and fishing strategies. This paper was prepared with the purpose of assessing certain biological and environmental aspects of *D. maculatus* in the Alvarado Lagoon, such as its diet, sex ratio and growth.

Materials and Methods

The Alvarado lagoon system is located at the Southeast region of the State of Veracruz, Mexico, and is comprised, from North to South, by the Camaronera, Buen Pais, Alvarado and Tlalixcoyan lagoons. It is located

between the following geographical coordinates: 18º 44' 00" and 18° 52' 15" latitude North and 95º 44' 00" and 95º 57' 00" longitude West (Flores & Méndez, 1982). A network of ten sampling stations was placed in areas with underwater vegetation and mud (Figure 1) monitored during the period from May 2015 through May 2017, covering the main climatic seasons in this area e.g. Dry Season, Rainy Season and Storm Season (known as "nortes").

The fish were caught with a 50 m long, 2.5 m. high cast fishing line and net with a mesh size of 2.5 cm. Organisms were fixed with 10% formalin by injecting it into their abdominal cavity, in order to stop the digestive processes. In the laboratory, they were classified using the taxonomic keys created by Hoese and Moore (1998); Castro *et al.,* (1999) and Carpenter (2002 a, b). The weight of each subject was recorded with a semi-analytic scale (+/- 0.01 g), and their total length and pattern were measured using a conventional ichthyometer (+/- 0.1 cm).

Research on biological aspects of a species, such as the composition of diet, sex ratio and growth, has traditionally been considered as a basic aspect in the knowledge of its biology and its role in the structure and function of the ecosystem. The stomach was removed from 30 to 50% of the total subjects for each capture, by sampling site, and the stomach contents were analyzed according to the Windell and Stephen criteria (Bagenal, 1978). The most widely used are the numerical, volumetric and gravimetric methods. If it is recognized that prey or food types ingested can stand out for their values, numerical, volumetric or gravimetric, it has been chosen to represent the results based on an index of importance that combines the parameters evaluated and whose results adjust the variations of each method. The preys were identified at the lowest possible taxonomical level considering their degree of digestibility, and, thereafter, quantified by applying the following methods: the frequency method, used to quantify the number of subjects of each food type, and the numerical method, where the number of stomachs in which a certain food type appeared is recorded. (Hyslop, 1980), integrating these methods to the Relative Importance Ratio, according to the following ratio:

IIR=%F+%N, where: IIR= relative importance ratio, %N = No. of stomachs where the prey is present and %F = Prey occurrence frequency.

The determination of the sex ratio and the changes in the stages of maturity are of enormous importance to acquire a complete knowledge of the general biology of an exploited population and are part of its fundamental evaluation. The gonads were removed to determine sex and gonadal maturity and observed under a stereoscopic microscope; the species' sex ratio was calculated by season, by using the following ratio: Number of Females/Number of Males.

To determine whether sex ratio adhered to the theoretical distribution of 1:1, the chi-square method (X^2) was used, with a significance level of $P<0.05$, according to Zar (2010).

The determination of age in fish is one of the most important aspects for the study of the dynamics of their populations. In addition to serving as a basis for calculations that allow to know the growth, mortality, recruitment and other parameters of its population. Two methods were used for calculating growth rate. The first one consisted in extracting an average of 10 scales from the rear part of the pectoral fin, taken from 30% of this species' specimens, including in the various sizes

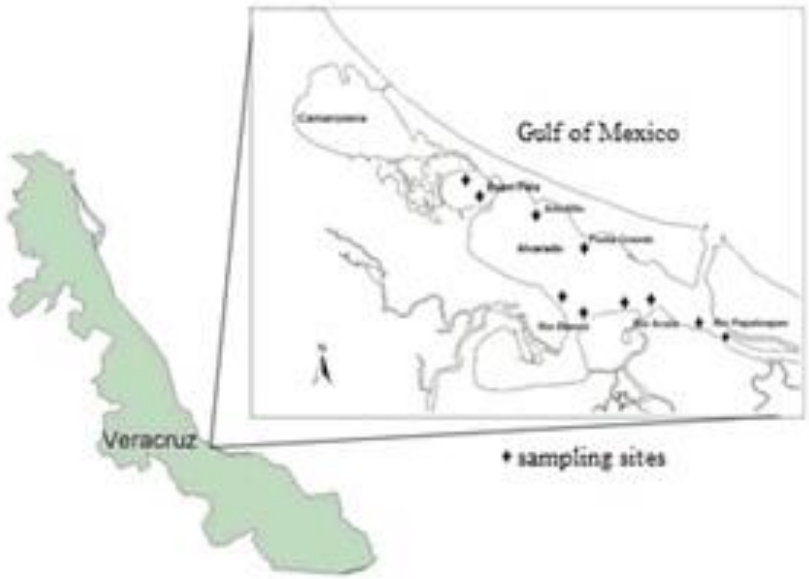

Figure 1. Location of the Alvarado Lagoon and of the sampling stations.

recorded. The criteria used for identifying and calculating growth rings were those proposed by the FAO (1982). The scales were washed with soap solution, with the help of a brush and once cleaned, they were mounted between two slides. The scales were checked with a stereoscopic microscope with direct light and transmitted at 10, 20 and 40 X. With the data of the standard length and the records of the marks on the scales, a table of number of marks vs the standard length was constructed.

The second method consisted in using the records on total length by sex and grouping all specimens by ten millimeter intervals, which allowed to obtain the size frequency rate, from which it was possible to establish sequential groups or classes by using the Cassie method (1954). Once such groups were obtained the asymptotic length (L_{max}), growth rate (k) and T_0 were calculated by using the Ford-Walford (Ford, 1933), Walford (1946) and Gulland and Holt (1959) methods.

Subsequently, the von Bertalanffy growth model (1938), was obtained, which adjusts the species' growth curve using their size class and length.

$Lt = L_{max} [1- e^{-k (t-to)}]$, where: Lt = average length of a certain size class (t), L_{max} = average or maximum asymptotic length reachable by a fish, K = growth rate or catabolism coefficient, to = adjustment parameter representing length when the hypothetical age is 0 and t = age expressed in periods of time.

The phi prime (Ø') growth ratio was calculated, to compare the species' growth with previous estimates, was obtained by using the following equation: Ø'=Log10 (K)+2 Log10 (L_∞) proposed by Pauly & Munro (1984).

Results

A total of 642 individuals were collected, 312 were females and 330 were male, with a sex ratio of 1:1.05 females per male. The sex ratio per season was 1:1.44 during the dry season, 1:1 during the rainy season and 1:1.04, during the storm season, females:males respectively. In general, sex stayed in a 1:1 ratio, both for the total specimens captured $X^2(1, N = 642) = 0.020$ $P<0.05$, and the seasons listed; hence, during the dry season $X^2(1, N = 132) = 1.6332$ $P> 0.05$, during the rainy season $X^2(1, N = 267) = 0.0$ $P<0.05$ and during the storm season $X^2(1, N = 243) = 0.020$ $P<0.05$.

The size and weight pattern for females, per season, during the dry season, their size interval ranged from 3.9 to 6.5 cm in total length, and their weight was between 1.2 and 4.7 g; during the rainy season, the size interval ranged from 8 to 13.5 cm, and their weight was between 14 and 46 g; on the other hand, during the storm season, the size interval ranged from 5.9 to 15.9 cm, and the weight was from 5 to 88.9 g. For the males, during the dry season their interval ranged from 3 to 5 cm, and their weight between 2 and 6.2 g; while, during the rainy season, their sizes ranged from 7.2 and 11.7 cm, and during the storm season, their sizes ranged between 5 to 14.7 cm in total length and a weight of 4 to 62.9 g.

Diet

The trophic spectrum for *D. maculatus* in the Alvarado Lagoon is comprised of nine different food types, mainly underwater vegetation (*Ruppia marítima*), benthic algae (*Fragilaria* sp, *Coscinodiscus* sp., Nitzschia sp., *Navicula* sp.) and detritus, and, in a lower proportion, by Tanaidacea belonging to the *Discapseudes* spp. genus, insect remains, ostracods and fish remains and debris (Table 1).

In specimens of smaller sizes, that is, with a total length ranging between 5 and 8 cm, their predominant trophic spectrum includes benthic algae, dinoflagellates, detritus and remains of *R. marítima*; on the other hand, the trophic spectrum of those organisms with sizes larger than 10 centimeters is wider and includes insect remains, ostracods, tanaideacea, fish remains and a larger amount of *R. marítima*.

Growth

Growth, expressed as a variation of any one of the dimensions of the subject belonging to a certain population in terms of time, produces a magnitude curve susceptible to gradually increase until reaching a maximum asymptotic value. For purposes of calculating fish growth, Froese and Binohlan (2000), have indicated the use of the distribution of size frequencies as a way to obtain a preliminary assessment of a certain fish population. Additionally, the analysis of the growth rings in anatomical structures has proven useful in

Table 1. Trophic spectrum of *Dormitator maculatus*, by size and % of IIR

Food types	3-5 cm	5-8 cm	8-11 cm	11-13 cm	13-15 cm	15-18 cm
Ruppia maritima	10	15	49.3	48.4	58.6	60
Neritina virginea	0	0	13.4	15.6	12	10.8
Diatoms	55	36	4.2	0	0	0
Detritus	12	25	12	15.8	12	13.1
Remains of fish	0	0	0	2.2	3.4	3
Discapseudes sp.	0	0	5.3	4.7	7.4	4.9
Ostracods	0	14	15	11.8	4.6	6.2
Dinoflagellates	23	10	0.8	0	0	0
Remains of insects	0	0	0	1.5	2	2

determining growth, from the determination of age classes in this group of organisms (Campana, 2001).

The maximum length values estimated for this species ranged between 19.5 and 22.7 cm maximum length (L_{max}), compared with those obtained from the subjects captured, which ranged between 14.7 and 15.9 cm. in total length, corresponding to the size of breeding females. The analysis on the growth of *D. maculatus*, calculated by using the frequency size method for females and males and the scale method, allowed for separation into six different size classes, which were used for calculating the constants in the von Bertalanffy growth models. The results obtained using Ford-Walford and Gulland & Holt models are shown in Table 2, as are the estimates for the phi prime (Ø') growth ratio for both methods, while the curves describing growth, for both methods, and are shown in Figure 2 and Figure 3.

An important aspect is the fact that the records on sizes of the *D. maculatus* specimens, specially the fraction of the sample of smaller sizes, is seldom represented, due to the fishing gear used and the spatial distribution of the species throughout the lagoon during most of the year; this might possibly indicate that the estimates on L_{max} obtained by size frequencies may be overestimated, in comparison with the results obtained using scale analysis.

Discussion

It is acknowledged that the structure and function of lagoon and coastal ecosystems is under the influence of the flow of fresh water from mainland runoffs and the effects of tides, which, together, are responsible for the increase of organic matter and the variations in salinity that affect the dynamics of biological components, particularly fish (Zedlder & Onuf, 1984). Among the broad range species located throughout the year in the Alvarado Lagoon, *D. maculatus* stands out, as is it a natural resource currently exploited by the inhabitants the shore of this lagoon (Flores & Zavala, 1982; Franco *et al.,* 1996); when the species travels from the wetlands of the Papaloapan River basin towards the bays of the lagoon with reproductive purposes, their population in the area increases significantly, and their capture supports artisanal fishing, regionally known as Naca fishing, through the exclusive use of females' mature gonads; additionally, this species in known for its resistance and tolerance to changes in salinity conditions when traveling to habitats with different characteristics, and thus, it is well-known for being an amphidrome species with a wide distribution throughout the Atlantic coast (Nordlie & Haney, 1993; Riede, 2004), a similar behavior to that reported by

Table 2. Constants of the von Bertalanffy growth models, by sex, for *D. maculatus*, (L_{max}) asymptotic length, (T_0) period of time when $l_t = 0$, (k) growth rate and value of phi prime (Ø') for both estimates

	Ford-Walford			Gulland & Holt			phi prima (Ø')	
	L_{max} (cm)	k	To	L (cm)	k	To	Ford-Walford	Gulland & Holt
Total length (females)	22.71	0.2085	0.2903	22.93	0.1674	-0.3135	2.031	1.944
Total length (males)	22.37	0.2078	0.2573	22.37	0.1719	-0.2725	2.017	1.934
scales of both sexes	19.51	0.2664	0.3885	19.51	0.2664	-0.3690	2.006	2.020
both methods (average)	20.40	0.2474	0.3468	20.40	0.2474	-0.3507	2.018	1.961

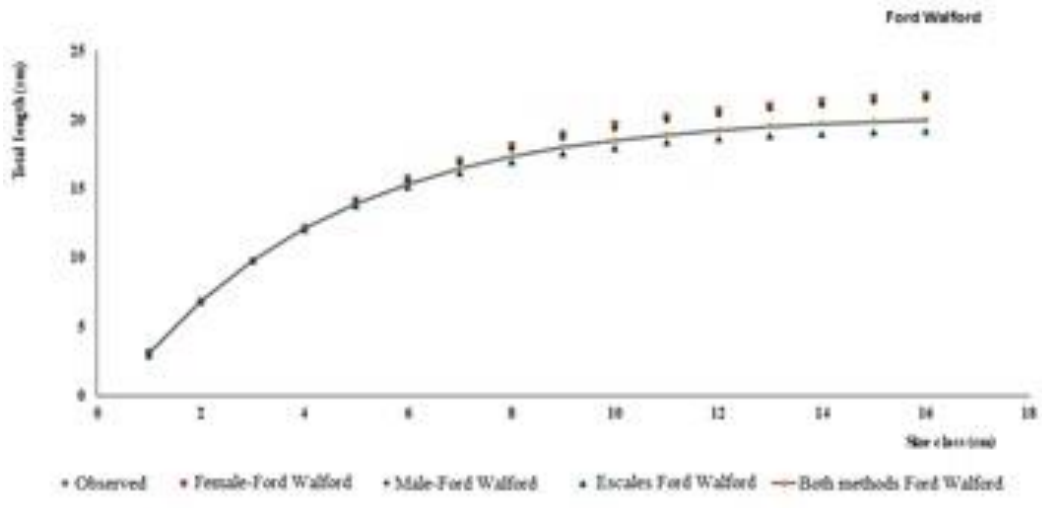

Figure 2. Curves for the von Bertalanffy growth models for *D. maculatus*, by size frequencies, by sex and by scales, with the Ford Walford adjustments.

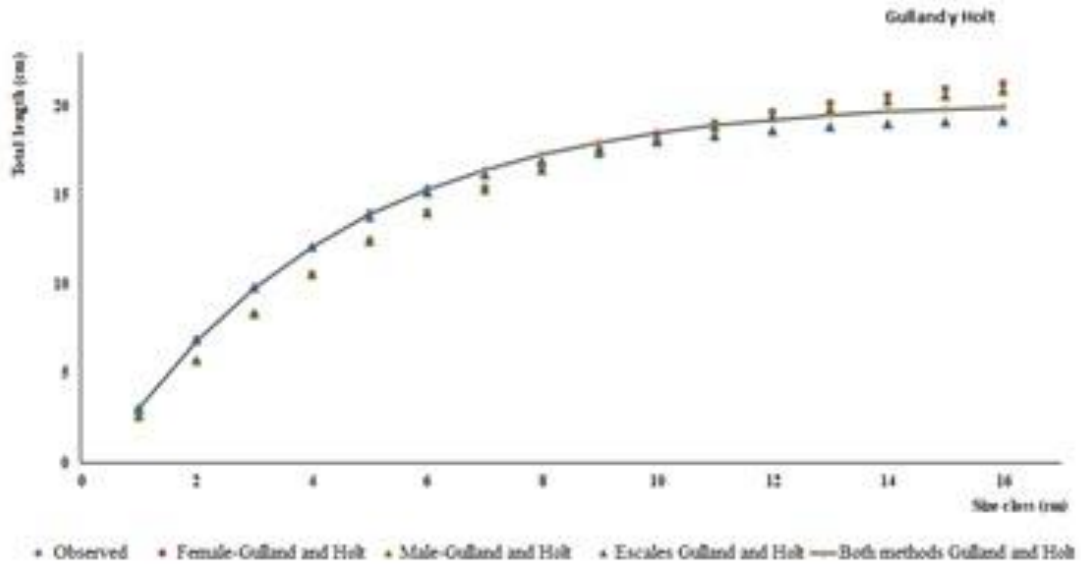

Figure 3. Curves for the von Bertalanffy growth model for *D. maculatus*, by size frequencies, by sex and by scales, with the Gulland & Holt adjustments.

Chang & Navas (1984), for the *Dormitator latifrons* Richardson, 1844 at the Chone River, in Ecuador, who mention that a weight estimate of 115 g/ha was reached in flood areas.

Based on the records of *D. maculatus* contained in available literature, it has been mentioned that it is a species that reproduces in the estuarine areas of some rivers at the Atlantic seaboard of the United States (Nordlie, 1979, 1981), Brazil (Teixeira, 1994), and Costa Rica (Winemiller & Ponwith, 1998), where the existence of sizes ranging from 15, to 75 and 125 mm or 380 mm in total length were reported by Robins and Ray (1986) for the Atlantic coast of North America, for females and males respectively, with a lifespan of three to five years. This data contrasts with that obtained in this work, where the males had a total maximum length of 14.7 cm, while females have a total maximum length of 15.9 cm, thus being larger and having a greater biomass than males, which reflects a similar result to that reported by Macossay-Cortez, Sánchez, Florido, Huidobro and Montalvo-Urgel (2011) for the Centla marshes in Tabasco. Winemiller and Ponwith (1998), mention that this species had the smallest sizes and the less developed gonads during the dry season, that is, between March and May, and that such behavior was also observed for the population in the Alvarado Lagoon, where the smallest sizes for both sexes were recorded during the dry season.

The sex ratio recorded for this species, that is, 1:1 females:males, is linked to the reproductive behavior; for this purpose, Monti, Keith and Vigneux (2010), have indicated that the changes in body color in this species are to sexual maturity prior to the reproduction, and that, also as a result of the reproduction courtship, the members of this species build nests that are protected by the adults once the eggs have been fertilized. Underwater vegetation, objects submerged in Water Lilies (*Eichhornia crassipes*) and roots of mangroves are mentioned as places chosen by this species to deposit eggs (Flores & Zavala, 1982; Nordlie, 1981, 2000).

The reproductive process of *D. maculatus* is linked to a considerable increase in rainfall (Delacroix & Champeau, 1992; Keith, 2003); under these conditions, it is considered that the intake of fresh water encourages the migration of this species towards the lower zones of estuaries and coastal lagoons (Delacroix & Champeau, 1992; Nordlie, 2000). This behavioral pattern is the same as that observed for the species at the Alvarado lagoon, where the population increases in the bays of the lagoon by the end of September or October, when the rainfall is more intense and thus facilitates the migration of the individuals from higher zones or habitats confined to the lagoon.

Additionally, the area has conditions favorable for the adequate development of both reproductive individuals, and larvae or juvenile individuals; due to the fact that there are food sources eaten during the time they spend in the lagoon. In this regard, the study performed by Teixeira (1994), at the Mundaú/Manguaba estuary, shows that *D. maculatus*, feeds, primarily, from macrophytes, sediments, including organic and inorganic matter and eggs, recording, additionally, consumption of fish, crustaceans, shellfish, insects and algae, which allows to classify it as an omnivore species. In this paper, this species' trophic spectrum reflected a detritus eating behavior in sizes close to five centimeters, predominantly diatomites, dinoflagellates, particles of organic matter and detritus, while the behavior in sizes over 10 centimeters are usually omnivore, consuming algae, remains of vegetation, insects and crustaceans, which reflects a similar behavior to that reported by

Nordlie (1981) in Costa Rica and Winemiller and Ponwith (1998) in Brazil.

Furthermore, the information available on other aspects of the life cycle of the *D. maculatus*, is scarce and fragmented, which makes it difficult to perform a full and comparative analysis on the behavior of this species in other locations. Regarding its life and reproductive cycle, it is mentioned that it could be similar to the Gobiidae suborder (Jonna & Weinheimer, 2003). Indicating that they may mature quickly, have a lifespan of only one to two years, and have territorial behavior (Thresher, 1984).

Regarding its growth, it has been observed that growth parameters differ from one species to another, and may even be different among populations of the same species that live in different locations or under different environmental conditions. In the case of *D. maculatus*, the results obtained using the von Bertalanffy model adjustments count not be compared, due to the scarce information available on this species, and were the only information available reported in literature, refers to the maximum sizes reached by *D. latifrons,* that is, 38 to 70 cm in maximum length, in Ecuador (Florencio & Serrano, 1981), or based on reports published by Nordlie (1979, 1981); Teixeira (1994) and Winemiller and Ponwith (1998) for *D. maculatus,* which report a maximum length of 12.5 cm, and larger sizes in males than in females, which results are not in line with those obtained in this study, since the maximum lengths obtained were 14.7 cm. in males and 15.9 cm in females, results that are more similar to that reported by Macossay-Cortez *et al.,* (2011), who reported a total length of 18.9 cm in Tabasco.

Growth curves for *D. maculatus* in length obtained using the von Bertalanffy model for each sex, and the calculation of the phi prima (Ø') growth index are the first estimates for this species in the state of Veracruz and, unfortunately, no previous information published on these determinations with which they could be compared was found for the species in the Gulf of Mexico.

The values of the parameters obtained using the total length frequency records clearly show the existence of L_{max} values higher than those obtained using scale readings, but with values lower than those of constants k and to, used for the adjustments of Ford-Walford and Gulland and Holt, which may be explained by the inverse correlation existing between L_{max} and k. An aspect observed while analyzing the results obtained for each sex, was that they only show slight variations and show that the females have larger growth values compared with those shown by males, reaching a larger average asymptotic length.

In the case of *D. maculatus*, in the Alvarado lagoon system, there is no information on the three aspects considered in the present work and nevertheless, the information obtained from the fishermen indicates that the sizes of this species at the time of capture, have decreased in recent years. This can be important because at higher fishing pressure, the larger sizes those individuals could reach, by participating in various reproductive events throughout their lives, cannot develop them, which translates into smaller reproductive individuals.

This report is considered a first approximation to the evaluation of some aspects related to the biology of this species in the study area, and from the information obtained, to be able to formulate a more complete study that includes aspects such as age and rate of growth, mortality, as well as collecting fishing information in the sites of purchase and sale of fishery products in the area.

It is important to emphasize that, as there is no sustainable management program for this species, it has been observed that the historic capture of eggs of *D. maculatus* at the Alvarado lagoon has decreased over time; the highest capture data were recorded at the late 1980s and early 1990s, when the maximum amount of eggs captured, during the season in which algae and seaweed were washed ashore, was 250 tons, recorded by the fishing office in Alvarado, Veracruz. However, in recent years, the information obtained from fishermen has allowed to estimate that the volume of eggs of this species currently captured has significantly decreased to less than 100 tons.

This can also result in an affectation to the population size of this species, since when females are exploited in advanced stages of maturation, the potential quantity of offspring that could result from reproductive events is constantly reduced and could generate changes in the sex ratio in the population of this species in the area.

Finally, this species environmental role has proven to be of utmost importance, since, aside from the commercial exploitation it supports, it is also eaten by various carnivore species of fish, such as sea bass (*Centropomus undecimalis* Bloch, 1792), birds like egrets (*Egretta caerulea* Linnaeus, 1758) (Montoya, Chávez & Franco, 2004), turtles (Altamirano, Soriano, De Sucre & Ramírez, 1996), and otters (*Lontra longicaudis* Olfers, 1818) (Ramon, 2000), for which a decrease in the population of *D. maculatus* endangers other species in the system. Thus, it is necessary to broaden the existing studies on this species in order to establish seasons and quotas for their capture and make it possible to reverse the population decease trends of this species, and allow for a recovery of the "Naca" in this lagoon. The records on *D. maculatus*, particularly on their size and weight, differ from that reported in the literature by various authors; combined with the lack of biological and environmental information on those sites located within our country on the existing documentary sources for this species, regarding their population, reproductive and growth parameters, indicate a need to increase the research of these aspects, allowing for the proposal of more sustainable exploitation criteria in the area. It is

acknowledged that this species is very important for the area, since it is exploited for commercial purposes by the fishermen of the Alvarado lagoon, and that, currently, is population shows a decrease that may endanger its exploitation, in addition to affecting other species that use it as their main source of food. It is considered that this aspect must be addressed in order to predict its possible impact on the environment in the productive exploitation systems involving this species in the lagoon system of Alvarado, Veracruz.

Acknowledgements

This work is part of the project titled "Estudio Biológico y Ecológico de los Sistemas Litorales del Estado de Veracruz", (Biological and Environmental Study of the Coastal Systems of the State of Veracruz), partially supported by the Research Division of the Iztacala School for Higher Studies of the National Autonomous University of Mexico. The authors wish to thank the Fishing Technician Tomas Corro Ferreiro and the fisherment of the Alvarado Lagoon, particularly Andrés Herrera (El Ganso), for their support in collecting all specimens.

References

Abarca-Arenas, L. G., Franco-López, J., Peterson, M. S., Brown-Peterson N. J. & Valero-Pacheco, E. (2007). Sociometric analysis of the role of penaids in the continental shelf food-web off Veracruz, Mexico based on by-catch. *Fisheries Research*, 87, 46-57. https://doi.org/10.1016/j.fishres.2007.06.019

Abarca, A. L. G., Cruz, N., Franco, J., González, L. C. G. & Silva, G. L. (2012). Distribution and biogeographical notes of the coastal fish fauna of Veracruz, Mexico. In D. Thangadurai, C. M. Buso, L. G. Abarca & S. Jayabalan (Eds.), *Frontiers in Biodiversity* (pp. 190-212). New Delhi, India: International Publishing House, Pvt. Ltd.

Altamirano A.T., Soriano, S. M., De Sucre, A. E. & Ramírez, P. B. (1996). Riqueza específica de la herpetofauna de Alvarado, Veracruz. *Revista de Zoología*, 2(número especial), 69-81.

Ancieta, C. F. & Landa, C. A. (1977). *Reseña taxonómica y biológica de los peces cultivados en el área andina incluyendo la costa del Perú*. Retrieved from http://www.fao.org/docrep/005/ac867s/AC867S09.htm

Bagenal, T. B. (1978). *Methods for assessment of fish production in freshwater*. Oxford, United Kingdom: Blackwell Scientific Publication.

Barrera, E. H., Franco, L. J., Zamudio, A. R. & Martínez, P. J. A. (2002). Maduración testicular e histológica de *Belonesox belizanus belizanus* (Osteichthyes: Poecilidae). *Revista de Zoología*, 13, 11-16.

Bedia, S. C. & Franco, L. J. (2014). *Peces de los sistemas costeros del estado de Veracruz*. Estado de México, México: Ediciones FES-Iztacala, UNAM.

Campana, S. E. (2001). Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. *Journal of Fish Biology*, 59, 197-242. https://doi.org/10.1111/j.1095-8649.2001.tb00127.x

Carbajal-Fajardo, Z. S., Franco L. J., Barrera, E. H, Abarca, A. L. G., Bedia, S. C., Moran, S. A. & Vázquez-López, H. (2009). Trophic seasonal behavior of the icthyofauna of Camaronera Lagoon, Veracruz. *Journal of Fisheries and Acuatic Science*, 4(2), 75-89. http://dx.doi.org/10.3923/jfas.2009.75.89

Carpenter, K. E. (2002a). *The living marine resources of the Western Central Atlantic. Volumen 2: Bony fishes part 1 (Acipenseridae to Grammatidae)*. Retrieved from http://www.fao.org/docrep/009/y4161e/y4161e00.htm

Carpenter, K. E. (2002b). *The living marine resources of the Western Central Atlantic. Volumen 3: Bony fishes part 2 (Ophistognathidae to Molidae).* Retyrieved from http://www.fao.org/docrep/009/y4162e/y4162e00.htm

Cassie, R. M. (1954). Some uses of probability paper in the analysis of size frequency distributions. *Australian Journal of Marine and Freshwater Research*, 5, 513-522. https://doi.org/10.1071/MF9540513

Castro, A. J. L., Espinosa, P. H. & Schmitter, S. J. J. (1999), *Ictiofauna estuarino-lagunar y vicaria de México.* Distrito Federal, México: IPN-Limusa.

Chang, B. D. & Navas, W. (1984). Seasonal variations in growth, condition and gonads of *Dormitator latifrons* (Richardson) in the Chone River Basin, Ecuador. *Journal of Fish Biology*, 24, 637-648. https://doi.org/10.1111/j.1095-8649.1984.tb04834.x

Chávez, L. R., Peterson, S. M., Brown, P. J. N., Morales, A. A. G. & Franco, L. J. (2005). Ecology of the mayan cichlid *Cichlasoma urophtalmus* Günther, in the Alvarado Lagoonal System, Veracruz, Mexico. *Gulf and Caribbean Research,* 17(1), 123-13. https://doi.org/10.18785/gcr.1701.13

Contreras-Espinosa, F., Castañeda, O. L., Barba, E. M. & Pérez, M. A. (2002). Caracterización e importancia de las lagunas costeras. In A. P. Guzmán, B. C. Quiroga, L. C. Díaz, C. D. Fuentes, M. C. Contreras & S. G. López (Eds.), *La pesca en Veracruz sus Perspectivas de Desarrollo* (pp. 31-35). México D.F.: SAGARPA/INP/UV.

Delacroix, P. & Champeau, A. (1992). Ponte en eau douce de Sicyopterus lagocephalus (Pallas) poisson Gobiidae amphibionte des rivières de la Réunion. *Hydroécologie Appliquée*, 4(1), 49-63. https://doi.org/10.1051/hydro:1992105

FAO. (1982). Métodos de recolección y análisis de datos de talla y edad para la evaluación de poblaciones de peces. *Circulares de Pesca* FAO, (736), 1-100.

Flores, C. C. & Zavala, G. F. (1982). Descripción de huevos y larvas de *Dormitator maculatus* (Bloch) de la Laguna de Alvarado, Veracruz (Pisces: Gobiidae). *Anales del Instituto de Ciencias del Mar y Limnología*, 9(1), 127-140.

Flores, C. C. & Méndez, M. L. V. (1982). Contribución al conocimiento del ictioplancton de la Laguna de Alvarado, Ver., México. *Anales del Instituto de Ciencias del Mar y Limnología*, 9(1), 141-160.

Florencio, A. & Serrano, M. (1981). Algunos aspectos sobre la biología del chame, *Dormitator latifrons*. *Revista de Ciencias del Mar y Limnología*, 1(1), 73-81.

Ford, E. (1933). An account of the herring investigations conducted at Plymouth during the Years from 1924 to 1933. *Journal of the Marine Biological Association of the United Kingdom*, 19(1), 305-384.

https://doi.org/10.1017/S0025315400055910

Franco, L. J., Peraza P. M. & Chávez, L. R. 1992. Comunidades de peces asociadas a praderas de *Ruppia maritima* en el Sistema Lagunar de Alvarado, Veracruz, México. *Revista de Zoología*, 3, 19-27.

Franco, L. J., Chávez, L. R., Peláez, R. E. & Bedia, S. C. (1996). Riqueza ictiofaunística del Sistema Lagunar de Alvarado, Veracruz. *Revista de Zoología*, 2(número especial), 17-32.

Franco-López, J., Abarca-Arenas, L. G., Barrera-Escorcia, H., Bedia-Sánchez, C., Rivera-Felix, V. & Corro-Ferreira, T. (2014). Seasonal patterns of abundance, growth, gonad development and feeding behavior of *Mugil curema* V., 1836 and *Mugil cephalus* L., 1758 in the Lagoon of Alvarado, Veracruz, Mexico. *Journal of Fisheries and Aquatic Science*, 9(3), 109-124. http://10.3923/jfas.2014.109.124

Franco-López, J., Santes-González, A. G., Abarca-Arenas, L. G., Bedia-Sánchez, C., Barrera-Escorcia, H, Martínez-Pérez, J. A., Peláez- Rodríguez, E. & Viveros-Legorreta, J. L. (2017). Ecology and reproduction of *Opsanus beta* (Actinopterygii: Batrachoididae) in the Alvarado Lagoon, Veracruz, Mexico. *Revista de Biología Tropical*, 65(4), 1381-1396. https://doi.org/10.15517/rbt.v65i4.27239

Froese, R. & Binohlan, C. (2000). Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. *Journal of Fish Biology*, 56, 758-773. https://doi.org/10.1111/j.1095-8649.2000.tb00870.x

Gulland, J. A. & Holt, S. J. (1959). Estimation of growth parameters for data at unequal time intervals. *ICES Journal of Marine Science*, 25(1), 47-49. https://doi.org/10.1093/icesjms/25.1.47

Hoese, H. D. & Moore, R. H. (1998). *Fishes of the Gulf of Mexico. Texas, Louisiana, and adjacent waters*. Texas, USA: A & M University Press.

Hyslop, E. J. (1980). Stomach contents analysis: a review of methods and their application. *Journal of Fish Biology*, 17, 411-429. https://doi.org/10.1111/j.1095-8649.1980.tb02775.x

Jonna, R. & Weinheimer, M. (2003). Eleotridae. *Web Animal de la diversidad*. Retrieved from http://animaldiversity.ummz.umich.edu/site/accounts/information/Eleotridae.html

Keith, P. (2003). Biology and ecology of amphodromous Gobiidae in the Indo-Pacific and the Caribbean regions. *Journal of Fish Biology*, 63, 831-847. https://doi.org/10.1046/j.1095-8649.2003.00197.x

Macossay-Cortez, A., Sánchez, A. J., Florido, R., Huidobro, L. & Montalvo-Urgel, H. (2011). Historical and environmental distribution of ichthyofauna in the tropical wetland of Pantanos de Centla, southern Gulf of Mexico. *Acta Ichthyologica et Piscatoria*, 41(3), 229-245. http://10.3750/AIP2011.41.3.11

Milstein, C. B. & Thomas, D. L. (1976). Fishes new or uncommon to the New Jersey coast. *Chesapeake Science*, 17, 198-204. https://doi.org/10.2307/1351198

Monti, D., Keith, P. & Vigneux, E. (2010). Atlas des poisons et des crustacés d'eau douce de la Guadeloupe. Muséum national d'Histoire naturelle, Paris (*Patrimoines naturels*), 69, 1-128.

Montoya, M. J., Osorio, S. D., Chavez, L. R. & Franco, L. J. (2004). Helmintos del pez *Dormitator maculatus* (Osteichthyes: Eleotridae) de Alvarado, Veracruz, México. *Revista de Biología Tropical*, 52(2), 393-396. http://dx.doi.org/10.15517/rbt.v52i2.15255

Montoya, M. J., Chávez, L. R. & Franco, L. J. (2004). Helminths from *Dormitator maculatus* (Pisces: Eleotridae) in Alvarado Lagoon, Veracruz, Mexico, and supplemental data for *Clinostomum complanatum* Rudoplhi, 1814 from *Egretta caerulea* (Aves: Ardeidae). *Gulf and Caribbean Research*, 16, 115-127. https://doi.org/10.18785/gcr.1601.19

Nordlie, F. G. (1979). Niche specificities of eleotrid fishes in a tropical estuary. *Revista de Biología Tropical*, 27, 35-50. https://doi.org/10.15517/rbt.v27i1.25688

Nordlie, F. G. (1981). Feeding and reproductive biology of eleotrid fishes in a tropical estuary. *Journal of Fish Biology*, 18, 97-110. https://doi.org/10.1111/j.1095-8649.1981.tb03764.x

Nordlie, F. G. & Haney, D. C. (1993). Euryhaline adaptations in the fat sleeper, *Dormitator maculatus*. *Journal of Fish Biology*, 43, 433-439. https://doi.org/10.1111/j.1095-8649.1993.tb00578.x

Nordlie, F. G. (2000). Patterns of reproduction and development of selected resident teleosts of Florida salt marshes. *Hydrobiologia*, 434, 165-182. https://doi.org/10.1023/A:1004073125007

Pauly, D. & Munro, J, L. (1984). Once more on growth comparison in fish and invertebrates. *Fishbyte*, 2(1), 21. Retrieved from https://econpapers.repec.org/article/wfiwfbyte/38103.htm

Peláez, R. E., Franco, L. J., Matamoros, W. A., Chávez, L. R. & Brown-Peterson, N. J. (2005). Trophic relationships of demersal fishes in the shrimping zone off Alvarado lagoon, Veracruz, Mexico. *Gulf and Caribbean Research*, 17, 157-167. https://doi.org/10.18785/gcr.1701.16

Quiroga, B. E, Valdéz, G., Hernández, I., García, M. & Guzmán, P. (2002). Peces ribereños. In A. P. Guzmán, B. C. Quiroga, L. C. Díaz, C. D. Fuentes, C. Contreras & L. G. Silva, (Eds.), *La pesca en Veracruz y sus perspectivas de desarrollo* (pp. 155-165). Veracruz, México: SAGARPA-INAPESCA.

Ramón, J. (2000). *Hábitos alimentarios de la nutria o perro de agua (Lontra longicaudis, Major) en una fracción del Río San Cipriano del Municipio de Nacajuca, Tabasco, México* (Thesis, Universidad Juárez Autónoma de Tabasco, Villahermosa, Tabasco, México).

Reséndez, M. A. (1973). Estudio de los peces de la Laguna de Alvarado, Veracruz, México. *Revista de la Sociedad Mexicana de Historia Natural,* 34, 183-281.

Riede, K. (2004). *Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081*. Bonn, Germany: Federal Agency for Nature Conservation.

Robins, C. R. & Ray, G. C. (1986). *A field guide to Atlantic coast fishes of North America*. Boston, U.S.A: Houghton Mifflin Company.

SAGARPA. (2005). *Alimentación sustentabilidad y pesca responsable: Evaluación y manejo*. México, D.F.: INAPesca/SEMARNAT.

SAGARPA. (2013). *Anuario estadístico de acuacultura y pesca*. Mazatlán, Sinaloa, México: CONAPESCA.

Salgado, M. G., Aguilar, R. A., Cabañas, G. C., Soto, E. G. & Mendoza, P. C. (2005). Helminth parasites in fresh water fish from the Papaloapan River Basin, Mexico. *Parasitology Research*, 96, 69-89. https://doi.org/10.1007/s00436-005-1315-9

Schwartz, F. J., Hogarth, W. T. & Weinstein, M. P. (1982). Marine and freshwater fishes of the Cape Fear estuary, North Carolina, and their distribution in relation to environmental factors. *Brimleyana*, 7, 17-37.

Taylor, D. S. (2001). Notes on collections of eleotrids from the Bay Islands, Honduras. *Bulletin of Marine Science*, 68(1), 153-155.

Teixeira, R. L. (1994). Abundance, reproductive period, and feeding habits of eleotrid fishes in estuarine habitats of north-east Brazil. *Journal of Fish Biology*, 45, 749-761. https://doi.org/10.1111/j.1095-8649.1994.tb00941.x

Thresher, R. E. (1984). *Reproduction in reef fishes*. Neptune City, NJ: T.F.H. Publications, British Crown Colony of Hong Kong.

von Bertalanffy, L. (1938). A quantitative theory of organic growth (inquiries on growth laws II). *Human Biology*, 10(2), 181-213.

Walford, L. A. (1946). A new graphic method of describing the growth of animals. *The Biological Bulletin*, 90(2), 141-147. https://www.journals.uchicago.edu/doi/abs/10.2307/1538217?journalCode=bbl

Weinstein, M. P. (1985). Distributional ecology of fishes inhabiting warm temperate and tropical estuaries: community relationships and implications. In A. Yanez-Arancibia (Ed.), *Fish community ecology in estuaries and coastal lagoons: Towards an ecosystem integration* (pp. 285-310). Ciudad de México, México: UNAM Press.

Winemiller, K. O. & Ponwith, B. J. (1998). Comparative ecology of Eleotrid fishes in Central American coastal streams. *Environmental Biology of Fishes,* 53(4), 373-384. https://doi.org/10.1023/A:1007422821071

Yánez-Arancibia, A. & Díaz-González, G. (1976). Ecología trofodinámica de *Dormitator latifrons* (Richardson) en nueve lagunas costeras del Pacifico de México (Pisces: Eleotridae). *Anales del Centro de Ciencias del Mar y Limnología*, 4 (1), 125-140.

Zar, J. H. (2010). *Biostatistical analysis*. New Jersey, USA: Prentice Hall.

Zarza-Meza, E. A, Berruecos-Villalobos, J. M, Vásquez-Peláez, C, & Álvarez-Torre, P. (2006). Cultivo experimental de robalo *Centropomus undecimalis* y chucumite *Centropomus parallelus* (Perciformes: Centropomidae) en estanques rústicos de tierra. *Ciencias marinas*, 32(2), 219-227. Retrieved from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185-38802006000400002&lng=es&tlng=es.

Zedler, J. B. & Onuf, C. P. (1984). Biological and physical filtering in arid-region estuaries: Seasonality, extreme events, and effects of watershed modification. In V. S. Kennedy (Ed.), *The estuary as a filter* (pp. 415-432). Orlando, Florida, USA: Academic Press. https://doi.org/10.1016/B978-0-12-405070-9.50025-6