

ANNALES



*Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies
Series Historia Naturalis, 32, 2022, 1*



UDK 5

ISSN 1408-533X
e-ISSN 2591-1783



ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies

Series Historia Naturalis, 32, 2022, 1

KOPER 2022

**UREDNIŠKI ODBOR/
COMITATO DI REDAZIONE/
BOARD OF EDITORS:**

Alessandro Acquavita (IT), Nicola Bettoso (IT), Christian Capapé (FR), Darko Darovec, Dušan Devetak, Jakov Dulčić (HR), Serena Fonda Umani (IT), Andrej Gogala, Daniel Golani (IL), Danijel Ivajnšič, Mitja Kaligarič, Marcelo Kovačič (HR), Andrej Kranjc, Lovrenc Lipej, Vesna Mačić (ME), Alenka Malej, Patricija Mozetič, Martina Orlando-Bonaca, Michael Stachowitzsch (AT), Tom Turk, Al Vrezec

**Glavni urednik/Redattore capo/
Editor in chief:**

Darko Darovec

**Odgovorni urednik naravoslovja/
Redattore responsabile per le scienze
naturali/Natural Science Editor:**

Lovrenc Lipej

Urednica/Redattrice/Editor:

Martina Orlando-Bonaca

Prevajalci/Traduttori/Translators:

Martina Orlando-Bonaca (sl./it.)

**Oblikovalec/Progetto grafico/
Graphic design:**

Dušan Podgornik, Lovrenc Lipej

Tisk/Stampa/Print:

Založništvo PADRE d.o.o.

Izdajatelja/Editori/Published by:

Zgodovinsko društvo za južno Primorsko - Koper / Società storica del Litorale - Capodistria[®]

Inštitut IRRIS za raziskave, razvoj in strategije družbe, kulture in okolja / Institute IRRIS for Research, Development and Strategies of Society, Culture and Environment / Istituto IRRIS di ricerca, sviluppo e strategie della società, cultura e ambiente[®]

**Sedež uredništva/Sede della redazione/
Address of Editorial Board:**

Nacionalni inštitut za biologijo, Morska biološka postaja Piran / Istituto nazionale di biologia, Stazione di biologia marina di Pirano / National Institute of Biology, Marine Biology Station Piran SI-6330 Piran / Pirano, Fornače/Fornace 41, tel.: +386 5 671 2900, fax +386 5 671 2901;

e-mail: annales@mbss.org, **internet:** www.zdjp.si

Redakcija te številke je bila zaključena 30. 06. 2022.

**Sofinancirajo/Supporto finanziario/
Financially supported by:**

Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS) in Mestna občina Koper

Annales - Series Historia Naturalis izhaja dvakrat letno.

Naklada/Tiratura/Circulation: 300 izvodov/copie/copies

Revija Annales, Series Historia Naturalis je vključena v naslednje podatkovne baze / La rivista Annales, series Historia Naturalis è inserita nei seguenti data base / Articles appearing in this journal are abstracted and indexed in: BIOSIS-Zoological Record (UK); Aquatic Sciences and Fisheries Abstracts (ASFA); Elsevier B.V.: SCOPUS (NL); Directory of Open Access Journals (DOAJ).

To delo je objavljeno pod licenco / Quest'opera è distribuita con Licenza / This work is licensed under a Creative Commons BY-NC 4.0.



Navodila avtorjem in vse znanstvene revije in članki so brezplačno dostopni na spletni strani <https://zdjp.si/en/p/annalesshn/> / The submission guidelines and all scientific journals and articles are available free of charge on the website <https://zdjp.si/en/p/annalesshn/> / Le norme redazionali e tutti le riviste scientifiche e gli articoli sono disponibili gratuitamente sul sito <https://zdjp.si/en/p/annalesshn/>



VSEBINA / INDICE GENERALE / CONTENTS 2022(1)

SREDOZEMSKI MORSKI PSI
SQUALI MEDITERRANEI
MEDITERRANEAN SHARKS**Farid HEMIDA, Christian REYNAUD & Christian CAPAPÉ**

Observations on Thresher Shark, *Alopias vulpinus* (Chondrichthyes: Alopiidae) from the Coast of Algeria (Southwestern Mediterranean Sea) 1
Opazovanja morskih lisic, Alopias vulpinus (Chondrichthyes: Alopiidae) ob alžirski obali (jugozahodno Sredozemsko morje)

Elif ÖZGÜR ÖZBEK & Hakan KABASAKAL

Notes on Smoothback Angel Shark, *Squatina oculata* (Squatiniformes: Squatinidae) caught in the Gulf of Antalya 9
Zapis o pegastih sklatih, Squatina oculata (Squatiniformes: Squatinidae), ujetih v Antalijskem zalivu

Alessandro PAGANO & Alessandro DE MADDALENA

Underwater Observations of the Rare Angular Roughshark *Oxynotus centrina* (Chondrichthyes: Squalidae) in the Waters of Santa Tecla (Sicily, Italy) 17
Podvodna opazovanja redkega morskega pršiča, Oxynotus centrina (Chondrichthyes: Squalidae) v vodah Sante Tecle (Sicilija, Italija)

Deniz ERGÜDEN, Deniz AYAS & Hakan KABASAKAL

Morphometric Measurements of Three Young Carcharhinid Species from Northeastern Levant (Mediterranean Sea) 25
Morfometrične meritve mladičev treh vrst morskih psov iz družine Carcharhinidae iz severnovzhodnega Levanta (Sredozemsko morje)

Hakan KABASAKAL

Projections on the Future of Deep-Sea Sharks in the Sea of Marmara, Where Deep Zones Are Threatened by Deoxygenation: a Review 35
Napovedi o prihodnosti globomorskih morskih psov v Marmarskem morju, ogroženem zaradi pomanjkanja kisika: pregled

BIOINVAZIJA

BIOINVASIONE
BIOINVASION

Alan DEIDUN, Bruno ZAVA & Maria CORSINI-FOKA

Distribution Extension of *Lutjanus argentimaculatus* (Lutjanidae) and *Psenes pellucidus* (Nomeidae) to the Waters of Malta, Central Mediterranean Sea 49
Širjenje areala vrst Lutjanus argentimaculatus (Lutjanidae) in Psenes pellucidus (Nomeidae) v malteške vode (osrednje Sredozemsko morje)

Sami M. IBRAHIM, Abdulraziq A. ABDULRRAZIQ, Abdulghani ABDULGHANI, Sara A.A. AL MABRUK, David SALVATORI, Bruno ZAVA, Maria CORSINI-FOKA & Alan DEIDUN

First Record of *Enchelycore anatina* (Muraenidae) from Libyan Waters and an Additional Record from Southern Italy (Western Ionian Sea) 59
Prvi zapis o pojavljanju kavljezobe murene Enchelycore anatina (Muraenidae) iz libijskih voda in dodatni zapis za južno Italijo (zahodno Jonsko morje)

Rasha Ali HENEISH & Samir Ibrahim RIZKALLA Morphometric and Meristic Characteristics of a New Record of Bluespot Mullet <i>Crenimugil seheli</i> (Pisces: Mugilidae) in Egyptian Mediterranean waters	67	Deniz ERGÜDEN & Cemal TURAN A Rare Occurrence of <i>Carapus acus</i> (Carapidae) in the Eastern Mediterranean, Turkey <i>Redko pojavljanje strmorinca Carapus acus (Carapidae) v vzhodnem Sredozemskem morju (Turčija)</i>	113
<i>Novi zapis o pojavljanju vrste Crenimugil seheli (Pisces: Mugilidae) v egiptovskih sredozemskih vodah in njene morfometrične in meristične značilnosti</i>			
Yana SOLIMAN, Adib SAAD, Vienna HAMMOUD & Christian CAPAPÉ Heavy Metal Concentrations in Tissues of <i>Siganus rivulatus</i> (Siganidae) from the Syrian Coast (Eastern Mediterranean Sea)	75	Laith JAWAD, Murat ŞIRİN, Miloslav PETRTÝL, Ahmet ÖKTENER, Murat ÇELIK & Audai QASIM Skeletal Abnormalities in Four Fish Species Collected from the Sea of Marmara, Turkey	119
<i>Vsebnost težkih kovin v tkivih marmoriranega morskega kunca Siganus rivulatus (Siganidae) iz sirske obale (vzhodno Sredozemsko morje)</i>		<i>Skeletne anomalije pri štirih vrstah rib iz Marmarskega morja (Turčija)</i>	
IHTIOLOGIJA ITTOLOGIA ICHTHYOLOGY			
Jihade ALAHYENE, Brahim CHIAHOU, Hammou EL HABOUZ & Abdelbasset BEN-BANI Length Based Growth Estimation of the Blue Shark <i>Prionace glauca</i> from the Moroccan Central Atlantic Coast	85	RAZMNÖŽEVALNA EKOLOGIJA ECOLOGIA RIPRODUTTIVA REPRODUCTIVE ECOLOGY	
<i>Dolžinsko-masni odnos in ocena rasti pri sinjem morskem psu (Prionace glauca) iz osrednje atlantske obale Maroka</i>			
Okan AKYOL, Altan LÖK & Funda ERDEM Occurrence of <i>Cubiceps gracilis</i> (Nomeidae) in the Eastern Mediterranean Sea	101	Amaria Latefa BOUZIANI, Khaled RAHMANI, Samira AIT DARNA, Alae Eddine BELMAHI, Sihem ABID KACHOUR & Mohamed BOUDERBALA Gonadal Histology in <i>Diplodus vulgaris</i> from the West Algerian Coast	137
<i>Pojavljanje klateža, Cubiceps gracilis (Nomeidae), v vzhodnem Sredozemskem morju</i>		<i>Histologija gonad pri navadnem šparu (Diplodus vulgaris) iz zahodne alžirske obale</i>	
Farid HEMIDA, Boualem BRAHMI, Christian REYNAUD & Christian CAPAPÉ Occurrence of the Rare Driftfish <i>Cubiceps gracilis</i> (Nomeidae) from the Algerian Coast (Southwestern Mediterranean Sea)	107	Cheikhna Yero GANDEGA, Nassima EL OMRANI, Rezan O. RASHEED, Mohammed RAMDANI & Roger FLOWER The Growth and Reproduction of Two Sparidae, <i>Pagrus caeruleostictus</i> and <i>Pagellus bellottii</i> in Northern Mauritanian Waters (Eastern Tropical Atlantic)	143
<i>Pojavljanje redkega klazeža Cubiceps gracilis (Nomeidae) z alžirske obale (jugozahodno Sredozemsko morje)</i>		<i>Rast in razmnoževanje dveh vrst pagrov, Pagrus caeruleostictus in Pagellus bellottii v severnih mavretanskih vodah (vzhodni tropski Atlantik)</i>	
Nassima EL OMRANI, Hammou EL HABO-UZ, Abdellah BOUHAIMI, Jaouad ABOU OUALID, Abdellatif MOUKRIM, Jamila GOZOULI, Mohammed RAMDANI, Roger FLOWER & Abdelbasset BEN-BANI The Reproductive Biology of the Pouting <i>Trisopterus luscus</i> from the Atlantic Coast of Morocco			
		<i>Reproduktivna biologija francoskega moliča (Trisopterus luscus) iz atlantske obale Maroka</i>	155

Mourad CHÉRIF, Rimel BENMESSAOUD & Christian CAPAPÉ

- Growth Patterns and Age Structure of *Mullus surmuletus* (Mullidae) from the Northern Coast of Tunisia (Central Mediterranean Sea) 173
Rastni parametri in starostna struktura progasti bradačev Mullus surmuletus (Mullidae) iz severne tunizijske obale (osrednje Sredozemsko morje)

FLORA
 FLORA
 FLORA

Martina ORLANDO-BONACA, Erik LIPEJ, Romina BONACA & Leon Lojze ZAMUDA

- Improvement of the Ecological Status of the *Cymodocea nodosa* Meadow near the Port of Koper 185
*Izboljšanje ekološkega stanja morskega travnika kolenčaste cimodoceje (*Cymodocea nodosa*) v bližini koprskega pristanišča*

FAVNA
 FAVNA
 FAVNA

Manja ROGELJA, Martin VODOPIVEC & Alenka MALEJ

- Cestum veneris* Lesueur, 1813 (Ctenophora) – a Rare Guest in the Northern Adriatic Sea 197
Cestum veneris Lesueur, 1813 (Ctenophora) – redenk gost v severnem Jadranu

Adla KAHRić, Dalila DELIĆ & Dejan KULIJER

- Notospermus annulatus* (Nemertea: Lineidae), a New Record for Bosnia and Herzegovina 205
Notospermus annulatus (Nemertea: Lineidae), prvi zapis o pojavljanju za Bosno in Hercegovino

Andrea LOMBARDO & Giuliana MARLETTA

- Report of an Interesting *Trapania* (Gastropoda: Nudibranchia: Goniodorididae) Specimen from Central Eastern Sicily 211
Zapis o zanimivem primerku iz rodu Trapania (Gastropoda: Nudibranchia: Goniodorididae) iz osrednje vzhodne Sicilije

Abdelkarim DERBALI & Othman JARBOUI

- Stock Assessment, Cartography and Sexuality of the Wedge Clam *Donax trunculus* in the Gulf of Gabes (Tunisia) 217
Ocena staleža, kartografija in spolnost klinaste školjke Donax trunculus v gabeškem zalivu (Tunizija)

Abdelkarim DERBALI, Aymen HADJ TAIEB & Othman JARBOUI

- Length-Weight Relationships and Density of Bivalve Species in the Shellfish Production Area of Zarzis (Tunisia, Central Mediterranean Sea) 229
Dolžinsko-masni odnos in gostota školjk na gojišču školjk v predelu Zarsisa (Tunizija, osrednje Sredozemsko morje)

Toni KOREN

- The Diversity of Moths (Lepidoptera: Heterocera) of Significant Landscape Donji Kamenjak and Medulin Archipelago, Istria, Croatia 237
Raznolikost nočnih metuljev (Lepidoptera: Heterocera) Pomembne pokrajine Donji Kamenjak in Medulinski arhipelag, Istra, Hrvaška

OCENE IN PEROČILA
 RECENSIONI E RELAZIONI
 REVIEWS AND REPORTS

Ines Mandić Mulec & Nives Ogrinc

- Recenzija knjige: Mikrobična biogeokemijska voda 263
 Kazalo k slikam na ovtiku 265
Index to images on the cover 265

received: 2022-03-23

DOI 10.19233/ASHN.2022.10

LENGTH-WEIGHT RELATIONS AND GROWTH ESTIMATES IN THE BLUE SHARK, *PRIONACE GLAUCA*, FROM THE CENTRAL ATLANTIC COAST OF MOROCCO

Jihade ALAHYENE & Brahim CHIAHOU

Chouaib Doukkali University, Faculty of Sciences, Department of Biology, El Jadida, Morocco
e-mail: jihad.20081@hotmail.com

Hammou EL HABOUZ & Abdelbasset BEN-BANI
National Fisheries Research Institute (INRH), Agadir, Morocco

ABSTRACT

The blue shark, *Prionace glauca*, is widely distributed in the Mediterranean and the Atlantic Ocean. The present study proposes a management plan for this species based on biological data, including length-weight relationships and other growth parameters, morphometry, and longevity. Regular biological sampling of the blue shark was carried out during a period of 24 months (October 2017–October 2019). Specimens were collected from the artisanal fishing boats operating off the Central Atlantic coast of Morocco, especially in the region of Sidi Ifni, and in seasonal acoustic surveys. A total of 7224 individuals were examined, including 3704 females and 3520 males. The total length (TL) ranged from 48 cm to 340 cm in females and 55 cm to 350 cm in males. Both sexes had a length-weight relationship of $W(t) = 10^{-6} * TL^{3.4283}$, indicating significant major allometry. The von Bertalanffy parameters for both sexes combined were $L_{\infty} = 413.59$ cm, $k = 0.20$ year⁻¹, and $t_0 = 0.76$. Longevity (t_{max}) was more than 17 years for males and females.

Key words: *Prionace glauca*, morphometry, length-weight, Von Bertalanffy parameters, longevity

RELAZIONI LUNGHEZZA-PESO E STIME DI CRESCITA NELLA VERDESCA, *PRIONACE GLAUCA*, LUNGO LA COSTA ATLANTICA CENTRALE DEL MAROCCO

SINTESI

La verdesca, *Prionace glauca*, è ampiamente distribuita nell'Oceano Atlantico e nel Mediterraneo. Il presente studio propone un piano di gestione per questa specie basato su dati biologici, tra cui il rapporto lunghezza-peso e altri parametri di crescita, morfometria e longevità. Il campionamento biologico regolare della verdesca è stato effettuato per un periodo di 24 mesi (ottobre 2017–ottobre 2019). Gli esemplari sono stati raccolti dai pescherecci artigianali che operano al largo della costa atlantica centrale del Marocco, in particolare nella regione di Sidi Ifni, e durante le indagini acustiche stagionali. In totale sono stati esaminati 7224 individui, di cui 3704 femmine e 3520 maschi. La lunghezza totale (TL) variava da 48 cm a 340 cm nelle femmine e da 55 cm a 350 cm nei maschi. Entrambi i sessi presentavano una relazione lunghezza-peso pari a $W(t) = 10^{-6} * TL^{3.4283}$, indicando una significativa maggiore allometria. I parametri di von Bertalanffy per entrambi i sessi combinati erano $L_{\infty} = 413,59$ cm, $k = 0,20$ anno⁻¹ e $t_0 = 0,76$. La longevità (t_{max}) era superiore ai 17 anni per entrambi i sessi.

Parole chiave: *Prionace glauca*, morfometria, lunghezza-peso, parametri di Von Bertalanffy, longevità

INTRODUCTION

The blue shark, *Prionace glauca* (Linnaeus, 1758), is an oceanic-epipelagic shark species in the Carcharhinidae family and among the most abundant and fished elasmobranchs in the world (Nakano & Stevens, 2008). It is classified by the IUCN Red List of Threatened Species as near threatened worldwide (Rigby et al., 2019) and critically endangered in the Mediterranean Sea (Serena et al., 2021). *P. glauca* is an oceanic and circumglobal shark inhabiting temperate and tropical waters and probably the widest ranging chondrichthyan, with his distribution range also extending into the Mediterranean Sea (Ebert & Stehmann, 2013). Blue shark's movements are strongly influenced by water temperature (Vas, 1990), and this species undergoes seasonal latitudinal migrations on both sides of the North Atlantic (Stevens, 1976; Casey, 1985; Silva et al., 1996), the South Atlantic (Hazin et al., 1991) and the North Pacific (Nakano, 1994). It is found in the same waters as other pelagic sharks and tuna species (*Isurus oxyrinchus*, *Xiphias gladius*, *Thunnus obesus*, and *T. thynnus*) (Cortés et al., 2010).

In Morocco, the blue shark is exploited by coastal and freezer longliners, as well as by the artisanal fleets operating along the Moroccan coast. The fishing gear used in the targeted fishery is mainly longline and, to a minor extent, the

so-called "bonitard" drifting gill net. The catch of artisanal boats that target sharks in the study area usually consists of about 85% blue sharks, 13% mako sharks, and 2% other species. According to fishing crews and wholesalers at the Sidi Ifni port, after the first vending for local consumption at the fish market in the port of Sidi Ifni, these sharks are shipped outside the region to other cities in Morocco. It is mainly sold in major markets. In addition, Morocco is an exporter of shark fins to European and Asian countries (Okes & Sant, 2019). The lack of basic scientific data on the blue shark in Morocco hampers the management of this species. Scientific monitoring was initiated for the better preservation of this shark. Moreover, except for Hamdi's study on the blue shark's growth, few elements are available in Morocco. Stock assessment depends on detailed size, age, and growth data (ICCAT, 2007). In the present study, authors report on the length-weight relationship (LWR) and growth parameters of *Prionace glauca*, based on a remarkable number of individuals, either captured in targeted fishery or captured as bycatch off the Central Atlantic coast of Morocco.

MATERIAL AND METHODS

Study area and sampling

The samples and measurements were taken at the Sidi Ifni port, located on the Central Atlantic coast of Morocco (latitude: 29°21'N - longitude: 10°11'W) about 170 km south of Agadir. The artisanal fishing area was between 10°W and 12°W longitude, and between 29°N and 31°N latitude, and was bound to the north by the coast of Aglou and to the south by a beach commonly known as Plage Blanche (Fig. 1). This area has a subtropical climate with surface water temperatures varying from 14 to 22.1°C. A total of 7224 blue sharks (3704 females and 3520 males) were sampled during a period of 24 months (October 2017–October 2019) from the artisanal fishing boats operating in the area, and in seasonal acoustic surveys carried out in spring (mid-March to May) and autumn (September to October) by the R/V Al Amir Abdallah of the National Institute of Fisheries Research (INRH).

Morphometrics

For each shark, total length (TL) with caudal fin in natural position, fork length (FL), standard precaudal length (PCL), distance between the tip of the snout and the origin of the first dorsal (D1L), and distance between the end of the snout and the origin of the pelvic fin (PvL) were measured over the curve of the body to the nearest centimetre (Ebert

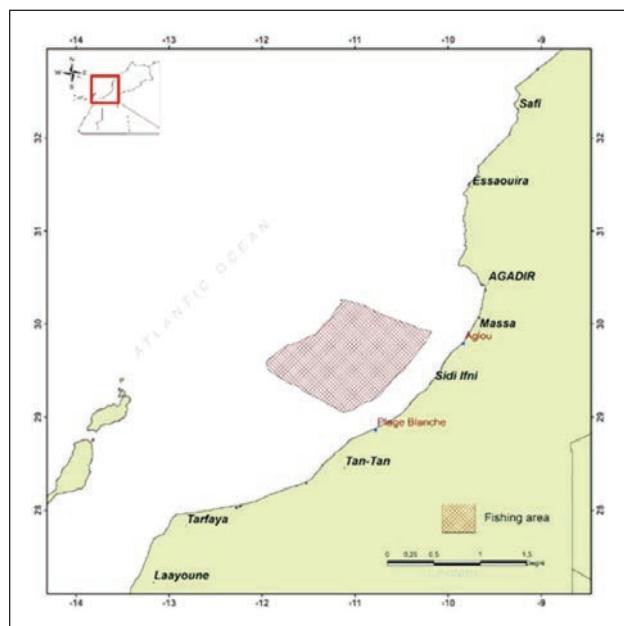


Fig. 1: Blue shark landing area at the port of Sidi Ifni.
Sl. 1: Območje iztovarjanja sinjega morskega psa v pristanišču Sidi Ifni.

& Stehmann, 2013). Body weight was measured to the nearest kg using an electronic scale. The sharks are not gutted at sea, so the body was whole when measured. The data were expressed as means \pm standard deviations (mean \pm SD).

The relationships between the different measurements were determined using a linear regression model (Alam et al., 2013):

$$Y = a + b * X$$

where Y and X are different body lengths (cm), a is the proportionality constant, and b is the coefficient of regression.

Following Le Cren (1951) and Ricker (1975), the relationship between the TL and weight was estimated as follows:

$$W(t) = a * L^b$$

where W is the body weight (kg), TL is the total length (cm), a is the intercept, and b is the slope of the relationship. When applying this formula to sampled fish, b may deviate from the "ideal value" of 3, which represents isometric growth, because of certain environmental circumstances or the condition of the fish themselves (Froese, 2006). When b is less than 3, it means that fish become slimmer with increasing length, and growth will be negatively allometric (minor). When b is greater than 3, it means that the fish become heavier, showing positive allometric (major) growth and reflecting optimum conditions for growth (Froese, 2006).

Von Bertalanffy growth parameters

Growth in length has been described using the von Bertalanffy (1938) growth equation based on either observed or back-calculated length at ages. The length frequency distribution analysis (LFDA) software sub-programme of the electronic length frequency analysis (ELEFAN) package is also a PC-based computer package for estimating growth parameters from fish length frequency distributions by the von Bertalanffy growth curve (Kirkwood et al., 2003). The ELEFAN procedure first restructures length frequencies and then fits a VBG curve to the restructured data. The standard von Bertalanffy growth function (VBGF) is as follows:

$$L(t) = L_\infty * (1 - e^{(-k * (t - t_0))})$$

where, L_t is length at age t , L_∞ is the asymptotic length to which the fish grows, k is the growth-rate parameter, and t_0 is the nominal age at which the length is zero.

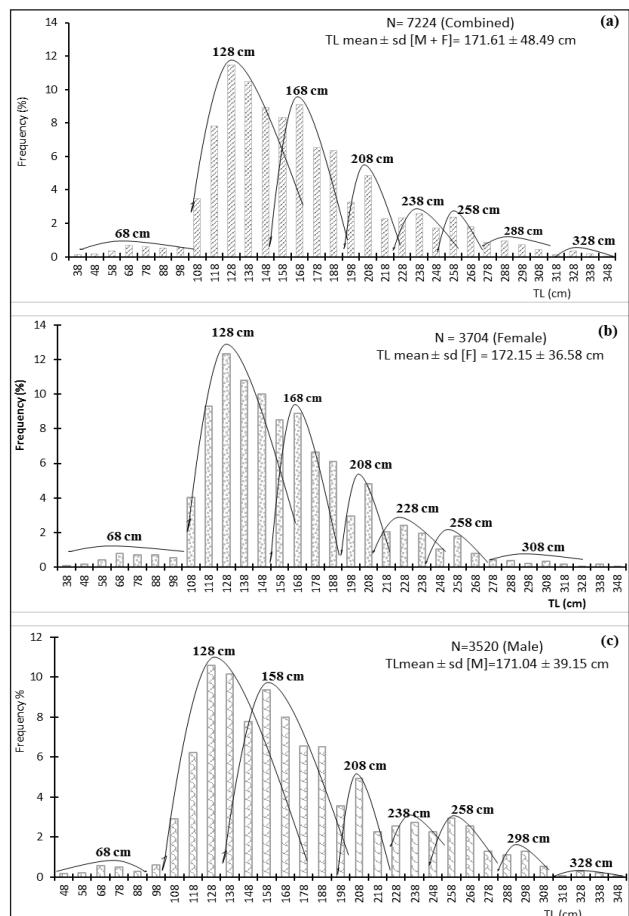


Fig. 2: Length frequency distributions for blue sharks caught off the Central Atlantic coast of Morocco during the Oct 2017–Oct 2019 period: (a) both sexes combined, (b) females, and (c) males.

Sl. 2: Velikostna porazdelitev sinjih morskih psov, ujetih ob obali srednjega Atlantika v Maroku v obdobju od oktobra 2017 do oktobra 2019, na podlagi dolžine: (a) obo spola skupaj, (b) samice in (c) samci.

Growth performance comparisons were made using the growth performance index (Φ'), which is preferred to the use of L_∞ and K individually (Pauly & Munro, 1984) and is computed as:

$$\Phi' = \log(K) + 2 \log(L_\infty).$$

Longevity

Theoretical longevity (t_{\max}) was estimated following Taylor (1958) and Fabens (1965). The respective equations for longevity based on the parameters of the VBGF following Taylor (1958) and Fabens (1965) are as follows:

$$t_{\max} = t_0 + 2.966/k \quad \text{and} \quad t_{\max} = 5(\ln 2)/k$$

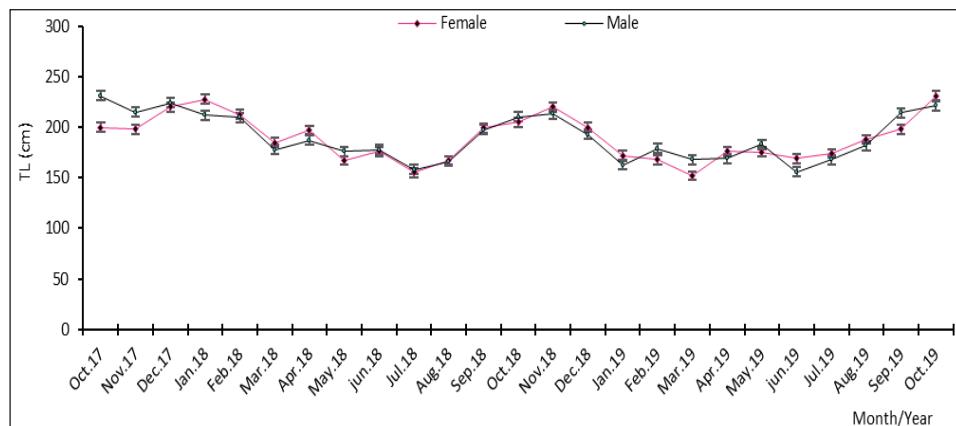


Fig. 3: Monthly median sizes of blue sharks landed at the port of Sidi Ifni during the October 2017–October 2019 period.

Sl. 3: Mesečne srednje velikosti sinjih morskih psov, ki so jih iztovorili v pristanišču Sidi Ifni v obdobju od oktobra 2017 do oktobra 2019.

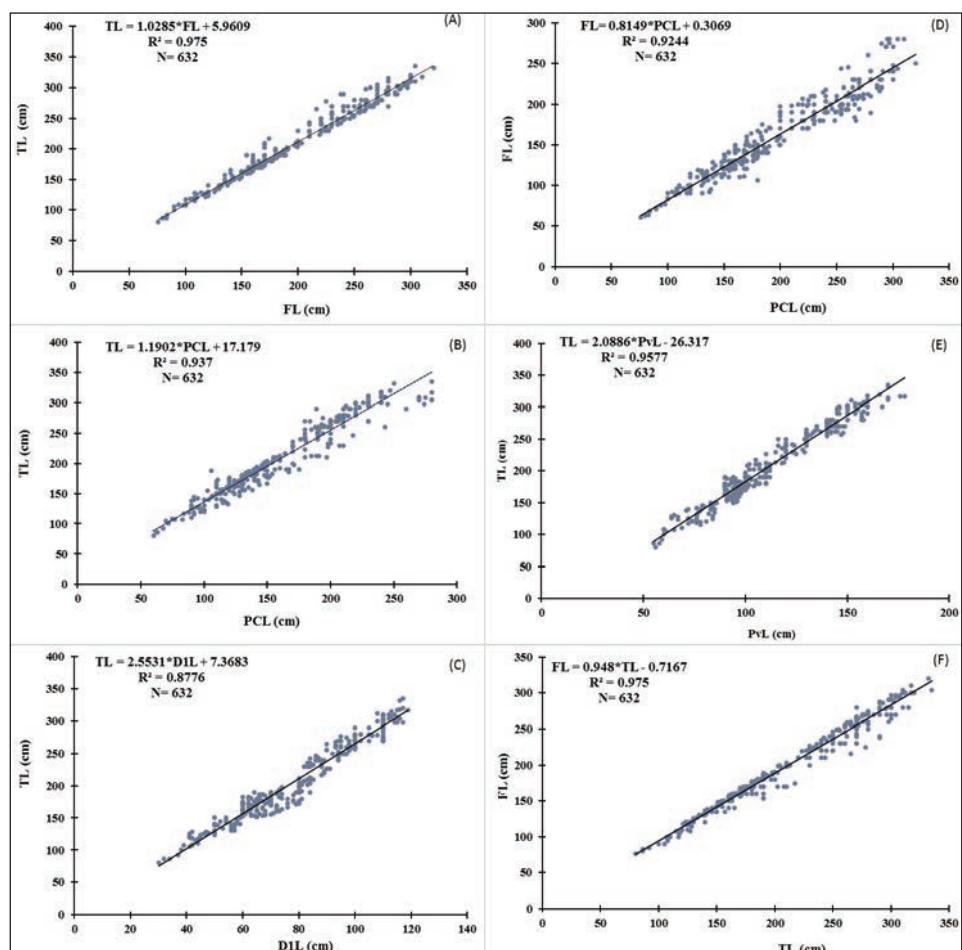


Fig. 4: Relationships between different length measurements of blue sharks landed at the port of Sidi Ifni during the period from October 2017 to October 2019.

Sl. 4: Odnosi med različnimi meritvami dolžine sinjih morskih psov, ki so jih iztovorili v pristanišču Sidi Ifni v obdobju od oktobra 2017 do oktobra 2019.

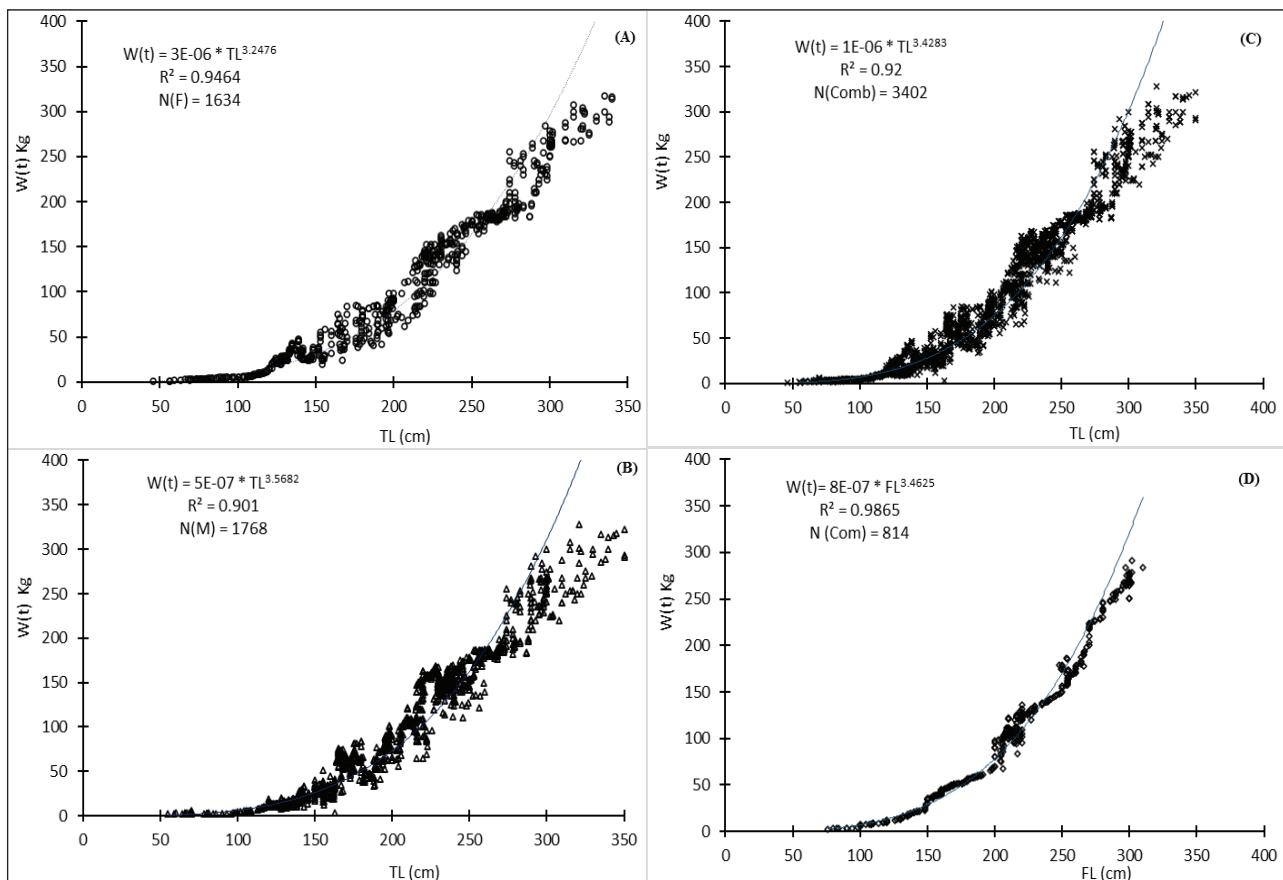


Fig. 5: LWR for blue sharks caught off the Moroccan Central Atlantic coast, for females (F), males (M), and the two sexes combined (Comb).

Sl. 5: LWR za sinje morske pse, ujete ob maroški centralni atlantski obali, za samice (F), samce (M) in oba spola skupaj (kombinirano).

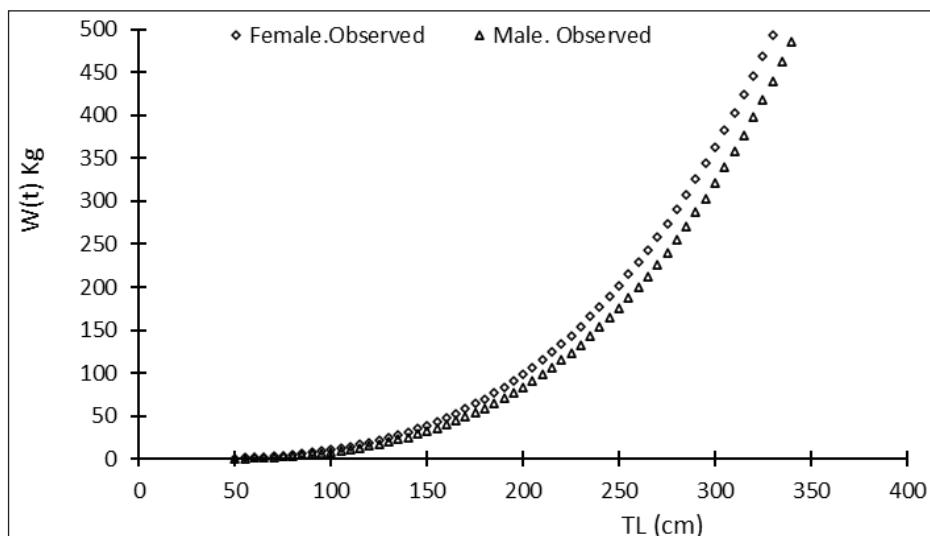


Fig. 6: LWR of *P. glauca* caught off the Central Atlantic coast of Morocco.

Sl. 6: LWR za primerke vrste *P. glauca*, ujete ob obali srednjega Atlantika v Maroku.

Tab. 1: Von Bertalanffy growth equation parameters of the blue shark.**Tab. 1: Parametri von Bertalanffyjeve rastne krivulje za sinjega morskega psa.**

Sex	N	L_{∞} (cm)	k (Year ⁻¹)	t_o	Φ'	t_{max} (Longevity)
Combined	7224	413.59	0.20	-0.76	4.53	14 - 17
Female	3704	398.58	0.18	- 0.01	4.45	16.4 - 19.2
Male	3520	435.72	0.17	- 0.23	4.50	17 - 20

Tab. 2: The size distribution of *P. glauca* in various regions of the world.**Tab. 2: Velikostna porazdelitev primerkov vrste *P. glauca* v različnih predelih sveta.**

Zone	Size (TL) cm	Size (FL) cm	Reference
Indian ocean	154 - 396	130 - 330	Gubanov et al., 1975
North-east Atlantic	64 - 218	55 - 183	Henderson et al., 2001
North-western Atlantic ocean	35 - 514	31 - 429	Kohler et al., 2002
South-west in the north Atlantic ocean	53 - 366	46 - 306	Kohler et al., 2002
North-eastern Atlantic ocean	37 - 305	32 - 255	Kohler et al., 2002
South-east coast of the north Atlantic ocean	70 - 349	60 - 292	Kohler et al., 2002
South West England ocean	80 - 219	68 - 184	Kohler et al., 2002
Portugal waters of Atlantic	40 - 159	35 - 134	Kohler et al., 2002
South-eastern Pacific ocean	56 - 310	—	Bustamante & Bennett, 2013
Moroccan waters	50 - 340	—	Hamdi et al., 2018
Present study	48 - 350	36 - 330	

RESULTS

Length frequency distribution

A total of 7224 blue sharks were examined, of which 3704 females (48–340 cm TL) and 3520 males (55–350 cm TL). The females were generally more numerous than males in all small and medium length classes [48–198 cm]. Contrarily, the males were more numerous than females in the remaining large length classes [200–350 cm] (Figs. 2 b, c). The length-frequency modes for each sex and sexes combined showed eight distinct modes: 68 cm – 128 cm – 168 cm – 208 cm – 238 cm – 258 cm – 288 cm – 328 cm (Figs. 2 a, b & c).

The monthly median sizes are shown in Fig. 3. The most common sizes varied between 130 and 225 cm (TL). Greater sizes (> 200 cm TL) were observed during autumn and in the beginning of winter (September, October, November, December, and January) in both

sexes. The largest observed size of 350 cm (TL) was recorded in October 2018. Smaller blue sharks (< 200 cm TL) are present during the winter, spring, and summer seasons.

Total length–fork length relationships

Morphometric studies are essential to determine the growth form and growth rate of a species, which is very important for a proper exploitation of a species' population. With reference to Figure 5, of the 7224 blue sharks, only the lengths of 632 sharks were compared. Relationships between TL & FL and other body measurements of *P. glauca* showed good linear regression with R^2 values ranging from 0.8776 to 0.975 (Fig. 4).

Length-weight relationship

The allometric equations between the two variables $W(t)$ and $L(t)$ showed a significantly major

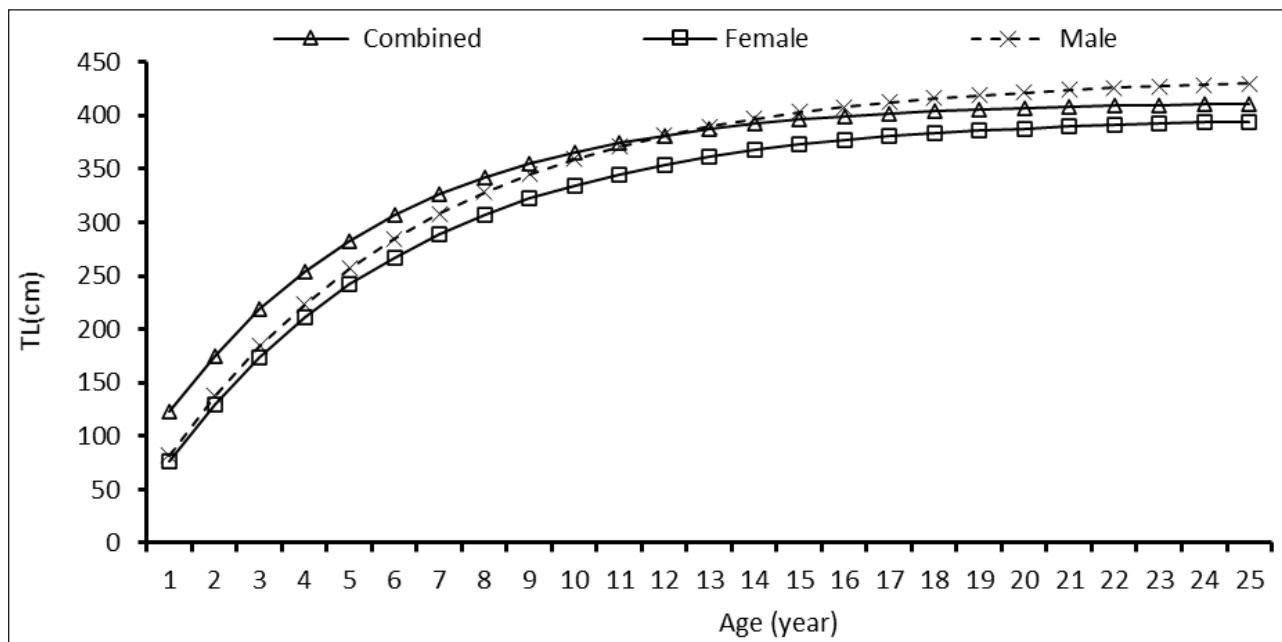


Fig. 7: The von Bertalanffy growth curves of blue sharks caught off the Central Atlantic coast of Morocco.
Sl. 7: Von Bertalanffyjeva rastna krivulja sinjih morskih psov, ujetih ob obali srednjega Atlantika v Maroku.

allometry (weight increasing faster than length) for males, females, and both sexes combined. The blue shark LWR parameters for males, females, and both sexes combined are shown in Fig. 5.

Figure 6 shows that the LWR for both sexes are similar. A comparison of the length-weight relationship in both sexes using the chi-square test contingency tables with 61 size classes ($n = 61$, $ddl = 60$) shows no significant difference between the LWR of both sexes ($X^2 = 2.5815 < 79.0819$ at $ddl = 60$ and $p = 0.05$) (Fig. 6).

Von Bertalanffy growth parameters

The growth performance indices (Φ') for both sexes were similar. The longevity estimates, following the methods of Taylor (1958) and Fabens (1965), were 14 and 17 years, respectively for the two sexes combined, 16.4 and 19.2 years, respectively, for females, and 17 and 20 years, respectively, for males (Tab. 1).

The representation of the von Bertalanffy growth equation curves for females and males of the blue shark shows that the males grow faster than females from the age of about 2 years onward, and are larger than females at any age thereafter (Fig. 7).

DISCUSSION

The size distribution of the blue sharks examined in the present study showed that the total exploited population was divided into eight modes. Hamdi et

al., (2018), who examined 505 blue sharks caught during between 2015 and 2017, sampled once a week at the fish market in Casablanca, Morocco, established more than 4 modes in their study, with the measured sizes between 50 cm and 340 cm TL. Males and females had average TL sizes of 184.37 cm and 164.71 cm, respectively. The most dominant sizes were between 120 and 150 cm TL. Large individuals predominated in June and December. The difference between Hamdi's study and the present one is that our samples were received from the landings of blue sharks at different ports in Morocco. Moreover, the size distribution of blue shark has been studied independently in several areas around the world and shows spatiotemporal variation (Tab. 2).

Several types of length measurement have been used by various researchers in describing shark morphometrics. Most commonly, these include total length (TL), fork length (FL), and precaudal length (PCL). There are several conversions that can be made between length types that have been developed and published. For the Atlantic Ocean and the Pacific North of the Japanese Ocean, Hazin et al. (1991) and McKinnell et al. (1998), respectively, reported relationships among TL, FL, and PCL. Kohler et al. (1996), Campana et al. (2005), Poisson (2007), and Castro et al. (1995) calculated the regression between TL and FL. Our study used all of these measurements, in addition to the distance between the tip of the snout and

Tab. 3: Relationships between different body sizes of *P. glauca* from regions around the world.**Tab. 3: Odnosi med različnimi telesnimi velikostmi pri vrsti *P. glauca* iz različnih predelov sveta.**

Region/ Author	N	Relational parameters	Size range (cm)	Regression equation	R ²
North central pacific (Nakano et al., 1985)	–	PCL / TL	–	PCL = - 0.2505 + 0.762* TL	–
Atlantic Ecuadorian Southwest (Hazin et al., 1991)	73	FL / TL	–	FL = 11.27 + 0.78* TL	0.94
		PCL / TL	–	PCL = 3.92 + 0.74* TL	0.95
Gulf of Guinea (Castro & Mejuto, 1995)	62	FL / TL	[117- 330]	FL = 1.061 + 0.8203* TL	0.9987
		TL / FL	[94- 273]	TL = 1.716 + 1.2158* FL	0.9987
Northwest Atlantic (Kholer et al., 1996)	572	FL / TL	–	FL = 1.308 + 0.831* TL	0.9966
Pacific North of the Japanese Ocean (Mckinnell et al., 1998)	187	PCL / TL	–	PCL = -1.95 + 0.76* TL	–
		TL / PCL	–	TL = 2.55 + 1.31* PCL	–
	242	TL / FL	–	TL = 3.62 + 1.35* FL	–
		FL / TL	–	FL = 2.68-0.70* TL	–
	190	FL / PCL	–	FL = 0.53 + 1.03* PCL	–
		PCL / FL	–	PCL = - 0.51 + 0.97 FL	–
Atlantic Canadian (Campana et al., 2005)	792	FL / TL	–	FL= - 1.2 + 0.842* TL	–
		TL / FL	–	TL = 3.8 + 1.17* FL	–
Indian Ocean (Poisson, 2007)	–	TL / FL	[130 - 330]	TL = 41.03 + 1.175* FL	–
Present study	632	TL / FL	[76 - 335]	TL = 5.9609 + 1.0285* FL	0.975
		TL / PCL	[60 - 335]	TL = 17.179 + 1.1902* PCL	0.937
		TL / D1L	[30 - 335]	TL = 7.368 + 2.5531* D1L	0.8776
		FL / PCL	[60 - 320]	FL = 15.079 + 1.1304* PCL	0.9244
		TL / PvL	[55 - 335]	TL = - 26.317 + 2.0886* PvL	0.9577
		FL / TL	[76 - 335]	FL = - 0.7167 + 0.948* TL	0.975

the origin of the first dorsal (D1L), and the distance between the end of the snout and the origin of the pelvic fin (PvL). Thus, we found linear regressions between the various body measurements which are in line with findings from other regions (Nakano et al., 1985; Hazin et al., 1991; Castro & Mejuto, 1995; Kholer et al., 1996; Mckinnell et al., 1998; Campana et al., 2005; Poisson, 2007) (Table 3). There are three length measurements (i.e., total length, fork length, and precaudal length) used as standard length in sharks (Francis, 2006). Precaudal length has only been used by Nakano & Seki (2003). It is recommended to use one of these three length measurements as a standard for measuring

the length of a shark to reduce the differences in the measured length of the shark.

The LWRs computed in the present study coincided with the equations computed for the populations of *Prionace glauca* occurring in the Pacific and Atlantic Oceans. Size increased proportionally but less rapidly than weight, and both sexes had similar weights at same lengths. This is contrary to the studies of Hamdi et al., (2018) in Moroccan water and of Harvey (1989) in the Bay of Monterey, California, which indicated isometric growth. While Hazin (1986) recorded a minor allometry in the Atlantic Ocean for females, the same result was recorded by Draganik & Pelczarski

Tab. 4: Parameters of the LWR (length-weight relationship) for the two sexes of the blue shark *P. glauca* combined from different study areas.**Tab. 4: Parametri LWR (razmerje med dolžino in maso) za oba spola sinjega morskega psa (*P. glauca*), združeni iz različnih raziskanih območij.**

Region /Authors	Sex	N	Length (cm)	$W(t) = a * L^b$	R ²	Allometry
Central Pacific (Strasburg, 1958)	Comb	-	TL	$W(t) = 4.018 * 10^{-6} TL^{3.134}$	-	Major
Atlantic Ocean (Stevens, 1975)	M	17	TL	$W(t) = 0.392 * 10^{-6} TL^{3.41}$	0.999	Major
	F	450	TL	$W(t) = 0.131 * 10^{-5} TL^{3.20}$	0.999	
Gulf of Guinea (Castro, 1983)	Comb	4529	TL	$W(t) = 3.18 * 10^{-6} TL^{3.1313}$	0.976	Major
Atlantic North (Draganik Pelczarski, 1984)	M	260	TL	$W(t) = 9.94 * 10^{-4} TL^{2.0005}$	-	Minor
	F	31	TL	$W(t) = 7.95 * 10^{-4} TL^{2.0473}$	-	
North Pacific Center (Nakano <i>et al.</i> , 1985)	M	285	TL	$W(t) = 3.838 * 10^{-6} TL^{3.174}$	0.997	Major
	F	148	PCL	$W(t) = 2.328 * 10^{-6} PCL^{3.294}$	0.994	
Atlantic Ocean (Hazin, 1986)	M	37	FL	$W(t) = 1.377 * 10^{-7} FL^{3.672}$	0.95	Major
	F	60	FL	$W(t) = 5.677 * 10^{-6} FL^{2.928}$	0.83	Minor
Monterey Bay, California (Harvey, 1989)	Comb	150	TL	$W(t) = 2.57 * 10^{-5} TL^{3.05}$	0.849	Isometric
Pacific North (Nakano 1994)	M	2910	PCL	$W(t) = 3.293 * 10^{-6} PCL^{3.225}$	0.993	Major
	F	2890	PCL	$W(t) = 5.388 * 10^{-6} PCL^{3.102}$	0.992	
Atlantic Northwest (Kohler <i>et al.</i> , 1996)	Comb	4529	FL; [52 - 288]	$W(t) = 3.84 * 10^{-6} FL^{3.1313}$	-	Major
Atlantic Northeast (Garcia-cortés & Mejuto, 2002)	Comb	354	FL; [75 - 250]	$W(t) = 8.04 * 10^{-6} FL^{3.232}$	-	Major
East tropical Atlantic (Garcia-Cortés & Mejuto, 2002)	Comb	743	FL; [120 - 260]	$W(t) = 0.638 * 10^{-6} FL^{3.278}$	-	Major
Central tropical Atlantic (Garcia-cortés & Mejuto, 2002)	Comb	164	FL; [140 - 245]	$W(t) = 0.956 * 10^{-6} FL^{3.209}$	-	Major
Southwest Atlantic (Garcia-cortés & Mejuto, 2002)	Comb	166	FL; [135 - 250]	$W(t) = 1.57 * 10^{-6} FL^{3.104}$	-	Major
Pacifique North (Joung, Hsu, Liu & Wu, 2011)	Comb	-	FL	$W(t) = 3 * 10^{-6} FL^{3.23}$	-	Major
Northeast Atlantic (Biton <i>et al.</i> , 2015)	Comb	102	TL	$W(t) = 2 * 10^{-6} TL^{3.1625}$	0.9575	Major
Moroccan waters (Hamdi <i>et al.</i> , 2018)	Comb	130	TL	$W(t) = 3 * 10^{-6} TL^{3.0389}$	0.9836	Isometric
	M	-	TL	$W(t) = 3 * 10^{-6} TL^{3.0504}$	0.9849	
	F	-	TL	$W(t) = 4 * 10^{-6} TL^{3.0123}$	0.9819	
Present Study	Comb	3402	TL; [48 - 350]	$W(t) = 10^{-6} TL^{3.4283}$	0.92	Major
		814	FL; [76 - 320]	$W(t) = 8 * 10^{-7} FL^{3.4625}$	0.9865	
	M	1768	TL; [55 - 340]	$W(t) = 5 * 10^{-7} TL^{3.5682}$	0.901	
	F	1634	TL; [48 - 350]	$W(t) = 3 * 10^{-6} TL^{3.2476}$	0.9464	

Tab. 5: Von Bertalanffy parameters (k , L_{∞} , and t_0) obtained by various authors for the blue sharks, for the sexes combined and separately.**Tab. 5: Von Bertalanffyjevi parametri (k , L_{∞} in t_0), ki so jih dobili različni avtorji za sinje morske pse, za spola skupaj in ločeno.**

Region / Authors	Sex	Length	L_{∞} (cm)	(*) L_{∞} Conversion to TL_{∞} (cm)	k (Year ⁻¹)	t_0 (Year)	t_{max} (Year) Longevity	Methods
Atlantic North (Aasen, 1966)	Comb	TL	394	394	0.133	-0.802	21.5 - 26	-
North East Atlantic (Stevens, 1975)	Comb	FL	309	423	0.110	-1.035	26 - 31.5	vertebrae
Northeast Pacific California (Cailliet et al., 1983)	Comb F M	TL	265.5 295.3 241.9	265.5 295.3 241.9	0.223 0.251 0.175	-0.80 -1.11 -0.80	12 - 15.5 10 - 13 16 - 19.8	vertebrae
Pacific Northwest (Tanaka, 1984) cited by (Nakano & Seki, 2003)	F M	PCL	256.1 308.2	338.9 408	0.116 0.094	-1.37	30 - 36.8	vertebrae
North Pacific (Nakano, 1994) cited by (Semba & Yokoi, 2016)	F M	PCL	243.3 289.7	321.9 383.5	0.144 0.12	-0.85 -0.759	19 - 24 23 - 28.8	vertebrae
North East Atlantic (Silva et al., 1996)	Comb F M	FL	284 382 309	339.96 457.87 370	0.14 0.09 0.12	-1.08 -1.19 -1.05	20 - 24.7 31.7 - 38 23.6 - 28.8	vertebrae
Atlantic (Henderson et al., 2001)	Comb	TL	376.5	376.5	0.120	-1.330	23 - 28.8	vertebrae
North Atlantic (Skomal & Natanson, 2003)	Comb F M	FL	286.8	341.16 343.8 337.9	0.17 0.130 0.180	-1.43 -1.77 -1.316	16 - 20.4 21 - 26.6 15 - 19.3	vertebrae and tags
Atlantic southwest (Hazin & Lessa, 2005)	Comb	TL	352	352	0.16	-1.01	17.5 - 21	vertebrae
Pacific (Manning & Francis, 2005)	F M	FL	342.9 267.5	320.11 410.81	0.126 0.088	-1.047 -1.257	22.5 - 27.5 32.4 - 39	-
Pacific Northwest Mexico (Blanco-Parra et al., 2008)	Comb F M	TL	303.4 237.5 299.8	303.4 237.5 299.8	0.10 0.15 0.10	-2.68 -2.15 -2.44	27 - 34.6 17 - 23 27.2 - 34	vertebrae
Mediterranean (Megalofonou et al., 2009)	Comb	TL	401.5	401.5	0.13	-0.62	22.2 - 26.6	vertebrae
Pacific North (Hsu et al., 2011), cited by (Semba & Yokoi, 2016)	F M	TL	317.4 375.8	317.4 375.8	0.172 0.121	-1.123 -1.554	16 - 20.4 23 - 28.6	-
South Africa (Jolly et al., 2013)	Comb F M	TL	311.6 334.7 294.6	311.6 334.7 294.6	0.12 0.11 0.14	-1.66 -2.19 -1.30	23 - 28.8 24.7 - 31.5 19.8 - 24.7	vertebrae
Pacific North (Fujinami et al., 2016), Cited by (Semba & Yokoi, 2016)	F M	PCL	256.3 284.8	339.2 377	0.147 0.117	-0.97 -1.34	19.2 - 23.5 24 - 29.6	-
Moroccan Waters (Hamdi et al., 2018)	Comb	TL	392.5	392.5	0.21	-0.402	13.4 - 16.5	size distribution

central South Pacific Ocean (Joung et al., 2018)	F M	TL	330.4 376.6	330.4 376.6	0.164 0.128	-1.29 -1.48	16.8 - 21 21.6 - 27	vertebrae
Southern of Nusa Tenggara Indonesia (Chodrijah et al., 2021)	F M	TL	400 390.5	400 390.5	0.28 0.25	-0.2921 -0.3307	10 - 13 11.5 - 14	size distribution
Present study	Comb F M	TL	413.59 398.58 435.72	413.59 398.58 435.72	0.20 0.18 0.17	-0.76 -0.01 -0.23	15 - 17.5 16.5 - 19 17 - 20	size distribution

(*): PRC = 0.76 * TL – 1.95 (Mc Kinnell & Seki, 1998). FL = 1.3908 + 0.8313 * TL (Kohler et al. 1996).

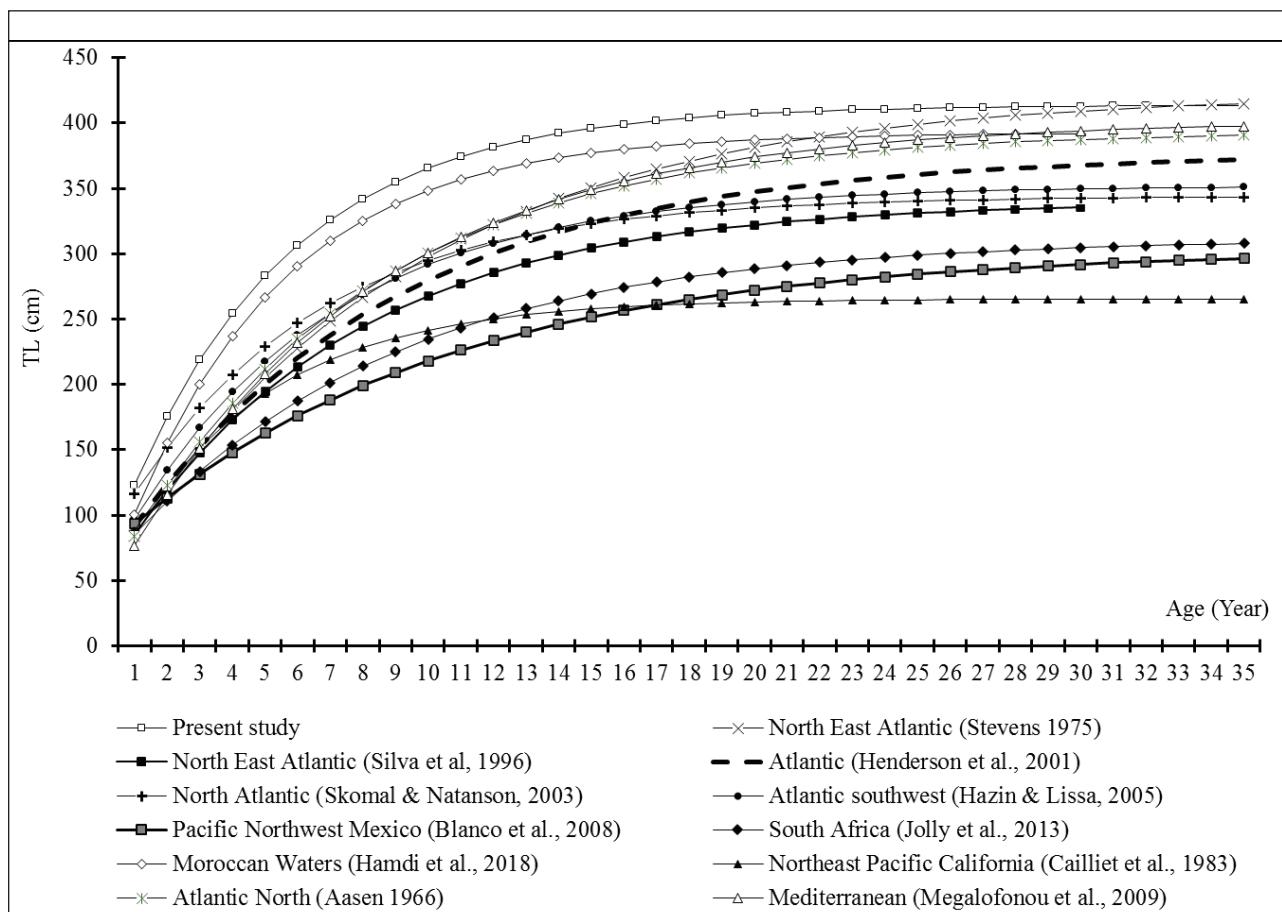


Fig. 8: Comparison of the von Bertalanffy growth curves for the sexes combined in different regions.
Sl. 8: Primerjava von Bertalanffyjevih krivulj rasti za oba spola iz različnih predelov.

(1984) in the North Atlantic for both sexes. This difference may be due to samples being taken from different places, at different times, and in different meteorological conditions, as well as to weighing on board, which may have led to errors during the weighing process. The comparison of the different equations is shown in Table 4.

The use of LFDA software (ELEFAN sub-program) allowed us to estimate the growth parameters of the targeted species in Central Atlantic Ocean

waters off the Moroccan coast. Length frequencies (LFDA software with ELEFAN subprogram) were used to calculate the von Bertalanffy parameters. Our k value was $0.20/\text{year}$. Branstetter (1987) categorized k values as follows: when a species grows slowly, the measured weight is $0.05 \leq k \leq 0.10 \text{ year}^{-1}$, intermediate growth is recorded when the weight is $0.10 \leq k \leq 0.20 \text{ year}^{-1}$, and rapid growth is recorded when the weight is $0.2 \leq k \leq 0.50 \text{ year}^{-1}$. Our study has shown intermediate growth for

this species in this region (Central Atlantic coast of Morocco), which is in agreement with Nakano, 1994; Henderson et al., 2001; Skomal & Natanson, 2003; Hazin & Lessa, 2005; Hsu et al., 2011; Jolly et al., 2013; Fujinami et al., 2016. However, other studies, such as Hamdi et al., (2018), Cailliet & Bedford (1983) and Chodrijah & Faizah (2021) reported large k values. In addition, studies from the Pacific reported a much higher maximum observed age (over 30 years) for both sexes compared to the estimates in the present study (between 15 and 20 years). These results suggest that the blue sharks in the Moroccan Central Atlantic have a shorter maximum life expectancy than those in some areas in the Pacific, Mediterranean, and North Atlantic. However, since the results of our study related to growth and longevity are consistent with those of several studies of water conducted in Morocco, Indonesia, California, the North Atlantic, and the Atlantic Southwest (Tab. 5), the differences observed in the lengths and weights of sharks may be due to the water temperature, since the latter has been found to importantly affect the growth rate (Simpfendorfer et al., 2002).

Our study showed a different growth rate between the sexes, similarly to studies from the Pacific (Tanaka et al., 1984; Nakano et al., 1994; Manning & Francis, 2005; Blanco-Parra et al., 2008; Hsu et al., 2011; Fujinami et al., 2016), where males were larger than females. In studies from South Africa (Jolly et al., 2013), the North Atlantic (Skomal & Natanson 2003), the Northeast Atlantic (Silva et al., 1996), and the Pacific Northeast California (Cailliet & Bedford, 1983) females were larger than males (Tab. 5). These regional differences may be due to migratory patterns, distribution, and movements of the blue shark, which are strongly influenced by seasonal variations, water temperature, reproductive conditions, and prey availability (Kohler et al., 2002). t_0 values are also extremely low for females; $t_0 = -0.01$ years is supposed to be an indication of gestation, including growth retardation, based on the assumption that intrauterine growth is the same as postpartum (Fujinami & Semba, 2016). Figure 8 shows that, generally, the growth rate of blue shark is rapid in the first years, slowing down during ages 10–15, and remaining constant beyond this age. Our study's growth curve is the highest and fastest ever recorded, conceivably due to the presence of a large number of newborns in this area and their absence in other study areas, which influenced our results (Fig. 8). Blue sharks grow faster than most

other shark species in the family Carcharhinidae (Branstetter & Stiles, 1987; Casey & Natanson, 1992), which makes them possibly the fastest growing shark species in general (Nakano & Stevens, 2008). The differences in sample sizes of each area precludes the conclusion that blue sharks in different regions have different growth characteristics. Also, other studies based on determining the age by counting vertebral rings have yielded different results than those using size frequencies.

CONCLUSIONS

This study provides biological parameters related to morphometrics and growth of the blue shark, *Prionace glauca*, in the Central Atlantic Coast of Morocco. Total lengths showed a multimodal distribution with a length range of 48–350 cm, where large individuals were observed in autumn and winter (September, October, November, December, and January). The morphometric study of the blue shark showed that the lengths measured between different points on the body of the specimens were proportional and in perfect positive correlation to total length (TL). Furthermore, the LWR study, in both sexes, showed a major growth allometry. In the Central Atlantic waters off the Moroccan coast, the blue shark seems to be growing faster than in other study areas. These findings could be applied to regional management of blue shark fishery. Additional studies on the reproductive cycles of females and local pupping areas are needed to protect neonates. Although Hamdi et al. (2018) have already shown that Morocco is a shark birthing site and nursery area, it is highly recommended that these be more accurately identified and protected to prevent the capture of young individuals.

ACKNOWLEDGEMENTS

The authors are very grateful to everyone who contributed to this valuable study. We would like to pay particular tribute to Mr. Bouaddi and all the fishing crews involved in small-scale fishing at the Sidi Ifni port, and the crew of the National Fishing Office of Sidi Ifni. Special thanks to all of them for their efforts to provide the researchers with ample information based on real facts and real findings gleaned from both their experience and direct contact with the blue shark. We would also like to thank anyone who helped directly or indirectly with this process. This study was supported by the National Institute of Fisheries Research in Agadir, Morocco.

DOLŽINSKO-MASNI ODNOS IN OCENA RASTI PRI SINJEM MORSKEM PSU (*PRIONACE GLAUCA*) IZ OSREDNJE ATLANTSKE OBALE MAROKA

Jihade ALAHYENE & Brahim CHIAHOU

Chouaib Doukkali University, Faculty of Sciences, Department of Biology, El Jadida, Morocco
e-mail: jihad.20081@hotmail.com

Hammou EL HABOUE & Abdelbasset BEN-BANI

National Fisheries Research Institute (INRH), Agadir, Morocco

POVZETEK

Sinji morski pes (*Prionace glauca*) je široko razprostranjen v Atlantskem oceanu in v Sredozemskem morju. Avtorji predlagajo za to vrsto načrt upravljanja, ki temelji na bioloških podatkih, vključno z dolžinsko-masnim odnosom in drugimi rastnimi parametri, morfometričnimi podatki in podatki o dolgoživosti. Sinjega morskega psa so redno vzorčili v obdobju 24 mesecev (oktober 2017 – oktober 2019). Primerke so lovili ribiči ob srednje atlantski obali Maroka, še posebej v regiji Sidi Ifni s tradicionalnimi plovili, in v sezonskih akustičnih raziskavah. Pregledali so skupno 7224 primerkov, med katerimi je bilo 3704 samic in 3520 samcev. Celotna dolžina pri samicah je bila od 48 cm do 340 cm in od 55 cm do 350 cm pri samcih. Oba spola sta imela dolžinsko-masni odnos $W(t) = 10^{-6} * TL^{3.4283}$, kar kaže na značilno veliko alometrijo. Parametri von Bertalanffyjeve enačbe za ova spola skupaj so bili $L_\infty = 413,59$ cm, $k = 0,20$ let $^{-1}$ in $t_0 = 0,76$. Dolgoživost (tmax) je bila višja od 17 let pri obeh spolih.

Ključne besede: *Prionace glauca*, morfometrija, dolžina-masa, Von Bertalanffyjevi parametri, dolgoživost

REFERENCES

- Aasen, O. (1966):** Blahaien *Prionace glauca* (Linnaeus). Fisker Hav 1, 1–15.
- Alam, M.M., S.M. Galib, M.M. Islam, F.A. Flowna & M.A. Hussain (2012):** Morphometric study of the wild population of pool barb *Puntius sophore* (Hamilton, 1822) in the River Padma, Rajshahi, Bangladesh. Trends in Fisheries Research, 1(2), 10–13.
- Biton, P.S.B., D. B naru, P. Béarez, I. Dekeyser, C.F. Boudouresque & F. Poisson (2015):** Ecology and Biology of the blue shark (*Prionace glauca*) and mako shark (*Isurus oxyrinchus*) in the northeast Atlantic: Implication for fishery management. Mar. Pollut. Bull., 127, 131–138. <https://hal.archives-ouvertes.fr/hal-01833596>.
- Blanco, P.M.D.P., M.F. Galván & F.F. Márquez (2008):** Age and growth of the blue shark, *Prionace glauca* (Linnaeus, 1758), in the Northwest coast off Mexico. Rev. biol. mar. oceanogr., 43(3), 513–520. <http://dx.doi.org/10.4067/S0718-19572008000300010>.
- Branstetter, S. (1987):** Age and growth estimates for blacktip, *Carcharhinus limbatus*, and spinner, *C. brevipinna*, sharks from the Northwestern Gulf of Mexico. Cop., 4, 964–974.
- Bustamante, C & M.B. Bennett (2013):** Insights into reproductive biology and fisheries of two commercially exploited species, shortfin mako (*Isurus oxyrinchus*) and blue shark (*Prionace glauca*), in the south-east Pacific Ocean. Fisheries Research, 143, 174–183. <https://doi.org/10.1016/j.fishres.2013.02.007>.
- Cailliet, G.M & D.W. Bedford (1983):** The biology of three pelagic sharks from California waters, and their emerging fisheries: a review. CalCOFI Rep., 24, 57–69.
- Campana, S.E., L. Marks, W. Joyce & N. Kohler (2005):** Catch, by-catch and indices of population status of blue shark (*Prionace glauca*) in the Canadian Atlantic. Collect. Vol. Sci. Pap. ICCAT, 58(3), 891–934.
- Casey, J.G. (1985):** Transatlantic migrations of the blue shark: A case history of cooperative shark tagging. In: Proceedings of the First World Angling Conference, Cap d'Agde, France, 12–18 September 1984 (ed. R. H. Stroud). World angling resources and challenges, pp. 253–267. <https://doi.org/10.1023/A:1007679303082>
- Casey, J.G & N.E. Kohler (1992):** Tagging studies on the shortfin mako shark (*Isurus oxyrinchus*) in the Western North Atlantic. Aust. J. Mar. Freshwater Res., 43, 45–60. <https://doi.org/10.1071/MF9920045>.
- Castro, J.I. (1983):** The sharks of North American waters. Texas A&M Univ. Press, College Station, TX, 180 pp.
- Castro, J.A & J. Mejuto (1995):** Reproductive Parameters of Blue Shark, *Prionace glauca*, and other sharks in the Gulf of Guinea. Mar. Freshwater Res., 46, 967–73.
- Cortés, E., F. Arocha, L. Beerkircher, F. Carvalho, A. Domingo, M. Heupel, H. Holtzhausen, M.N. Santos, M. Ribera & C. Simpfendorfer (2010):** Ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. Aquatic Living Resources, 23(1), 25–34. <https://doi.org/10.1051/alr/2009044>.
- Chodrijah, U. & Faizah, R (2021):** Population parameter, size distribution and sex ratio of the blue shark *Prionace glauca* Linnaeus, (1758) caught in the southern of Nusa Tenggara. IOP Conf. Ser.: Earth Environ. Sci., 890(1), 012054.
- Draganik, B. & W. Pelczarski (1984):** The occurrence of the blue sharks, *Prionace glauca* (L.), in the North Atlantic. Rep. sea Fish. Inst., 19, 61–75.
- Ebert, D.A., & M.F.W. Stehmann (2013):** Sharks, batoids, and chimaeras of the North Atlantic. FAO Species Catalogue for Fishery Purposes. No. 7. Rome, 523 pp.
- Fabens, A.J. (1965):** Properties and fitting of the von Bertalanffy growth curve. Growth, 29, 265–289.
- Francis, M.P. (2006):** Morphometric minefields – towards a measurement standard for chondrichthyan fishes. Environ Biol Fish 77, 407–421. <https://doi.org/10.1007/s10641-006-9109-1>.
- Froese, R. (2006):** Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22(4), 241–253.
- Fujinami, Y., Y. Semba, H. Ijima & S. Tanaka (2016):** Age and growth estimation of the blue shark, *Prionace glauca*, in the western North Pacific Ocean. ISC Shark Working Group. ISC document ISC/16/SHARKWG-1/02.
- García-Cortés, B. & J. Mejuto (2002):** Size-weight relationships of the swordfish (*Xiphias gladius*) and several pelagic shark species caught in the Spanish surface longline fishery in the Atlantic, Indian and pacific oceans. Collect. Vol. Sci. Pap. ICCAT, 54(4), 1132–1149.
- Gubanov, Y. & V.N. Grigor'yev (1975):** Observations on the distribution and biology of the blue shark *Prionace glauca* (Carcharhinidae) of the Indian Ocean. J. Ichthyol., 15, 37–43.
- Hamdi, H., S. Elamrani & N. Charouki (2018):** Preliminary study of blue shark *Prionace glauca* growth in Moroccan waters. Am. J. innov. res. appl. sci., 7(2), 118–129. <http://creativecommons.org/licenses/by-nc/4.0/>.
- Harvey, J.T. (1989):** Food habits, seasonal abundance, size, and sex of the blue shark, *Prionace glauca*, in Moterey bay, California. Calif. Fish Game, 75(1), 33–44.
- Hazin, F.H.V. (1986):** Pesca de atuns e afins com embarcação de pequeno porte no nordeste brasileiro. Graduation thesis, Universidade Federal Rural de Pernambuco. Recife, Brazil, 107 pp.

- Hazin, F.H.V., R. Lessa, M. Ishino, K. Otsuka & K. Kihara (1991):** Morphometric description of the blue shark, *Prionace glauca*, from the southwestern equatorial Atlantic. J. Tokyo Univ. Fish., 78, 137-144. <https://doi.org/10.2331/fishsci.60.487>.
- Hazin, F. & R. Lessa (2005):** Synopsis of biological information available on blue shark, *Prionace glauca*, from the southwestern Atlantic Ocean. Collective Volume of Scientific Papers ICCAT, 58(3), 1179-1187.
- Henderson, A.C., K. Flannery & J. Dunne (2001):** Observations on the biology and ecology of the blue shark in the north-east Atlantic. J. Fish Biol., 58(5), 1347-1358. <https://doi.org/10.1111/j.1095-8649.2001.tb02291.x>.
- Hsu, H.H., S.J. Joung, G.T. Lyu, K.M. Liu & C.C. Huang (2011):** Age and growth of the blue shark, *Prionace glauca*, in the northwest Pacific. ISC Shark Working Group Workshop. ISC document ISC/11/SHARKWG-2/16.
- Jolly, K.A., C. Da Silva & C.G. Attwood (2013):** Age, growth and reproductive biology of the blue shark *Prionace glauca* in South African waters. Afr. J. Mar. Sci., 35, 99-109. <https://doi.org/10.2989/1814232X.2013.783233>.
- Joung, S.J., H.H. Hsu, K.M. Liu & T. Wu (2011):** Reproductive biology of the blue shark, *Prionace glauca*, in the north-western Pacific. ISC Shark Working Group Workshop. ISC document ISC/11/SHARKWG-2/12. <https://doi.org/10.1071/MF16101>.
- Joung, S.J., G.T. Lyu, H.H. Hsu, K.M. Liu & S.B. Wang (2018):** Age and growth estimates of the blue shark *Prionace glauca* in the central South Pacific Ocean. Marine and Freshwater Research, 69(9), 1346. <https://doi.org/10.1071/MF17098>.
- Kirkwood, G.P., R. Aukland & S.J. Zara (2003):** Length Frequency Distribution Analysis (LFDA). Version 5.0. MARAG Ltd., London, UK. <https://agris.fao.org/agris-search/search.do?recordID=GB2012105230>.
- Kohler, N.E., J.G. Casey & P.A. Turner (1996):** Length-Length and Length-Weight Relationships for 13 Shark Species from the Western North Atlantic. Nat. Mar. Fish. Serv., Narragansett, RI 02882, 29 pp.
- Kohler, N.E., P.A. Turner, J.J. Hoey, L.J. Natanson & R. Briggs (2002):** Tag and recapture data for three pelagic shark species: blue shark (*Prionace glauca*), Shortfin mako (*Isurus oxyrinchus*), and porbeagle (*Lamna nasus*) in the north Atlantique Ocean. Col.Vol. Sci.Pap. ICCAT, 54(4), 1231-1260.
- Le Cren, E. (1951):** The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). The Journal of Animal Ecology: 201-219. <https://doi.org/10.2307/1540>.
- Manning, M.J & M.P. Francis (2005):** Age and growth of blue shark (*Prionace glauca*) from the New Zealand Exclusive Economic Zone. Ministry of Fisheries, Wellington, New Zealand.
- Megalofonou, P., D. Damalas & G. De Metrio (2009):** Biological characteristics of blue shark, *Prionace glauca*, in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom, 89(6), 1233-1242. <https://doi.org/10.1017/S0025315409000216>.
- McKinnell, S. & M.P. Seki (1998):** Shark bycatch in the Japanese high seas squid driftnet fishery in the North Pacific Ocean. Fish. Res., 39, 127-138. [https://doi.org/10.1016/S0165-7836\(98\)00179-9](https://doi.org/10.1016/S0165-7836(98)00179-9).
- Nakano, H., M. Makihara & K. Shimazaki (1985):** Distribution and biological characteristics of the blue shark in the central North Pacific. Bull. Fac. Fish. Hokkaido Univ., 36, 99-113. <https://agris.fao.org/agris-search/search.do?recordID=JP19870016673>.
- Nakano, H. (1994):** Age, reproduction and migration of blue shark in the North Pacific Ocean. Bulletin of the Natural Research Institute of Far Seas Fisheries, 31, 141-256. <https://agris.fao.org/agris-search/search.do?recordID=JP9501973>.
- Nakano, H & M.P. Seki (2003):** Synopsis of biological data on the blue shark, *Prionace glauca* Linnaeus. Bull. Fish. Res. Agency Japan, 18-55. <https://agris.fao.org/agris-search/search.do?recordID=JP2003005631>.
- Nakano, H & J.D. Stevens (2008):** The biology and ecology of the blue shark, *Prionace glauca*. In: Camhi, M.D., Pikitch, E.K., Babcock, E.A. (Eds.), Sharks of the Open Ocean: Biology, Fisheries and Conservation. Blackwell Publishing Ltd., Oxford, UK, pp. 140-151.
- Okes, N & G. Sant (2019):** An overview of major shark traders, catchers and species. TRAFFIC, Cambridge, UK.
- Pauly, D & J.L. Munro (1984):** Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte, 2(1), 21.
- Pilling, G.M., A.J.R. Cotter & J.D. Metcalfe (2007):** ICCAT FIELD MANUAL: Chapter 4. Data for Assessment and Research. <https://www.iccat.int>.
- Poisson, F. (2007):** Compilation of information on blue shark (*Prionace glauca*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*Carcharhinus longimanus*), scalloped hammerhead (*Sphyrna lewini*) and shortfin mako (*Isurus oxyrinchus*) in the Indian Ocean. IOTC--WPEB-INF01. <https://archimer.ifremer.fr/doc/00130/24142/>.
- Ricker, W.E. (1975):** Calculation and interpretation of biological statistics of fish populations. Bull. Fish. Board Can, 191F, 409 pp.
- Rigby, C.L., R. Barreto, J. Carlson, D. Fernando, S. Fordham, M.P. Francis, K. Herman, R.W. Jabado, K.M. Liu, A. Marshall, N. Pacoureau, E. Romanov, R.B. Sherley & H. Winker (2019):** *Prionace glauca*. The IUCN Red List of Threatened Species. <http://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T39381A2915850.en>.

Semba, Y & H. Yokoi (2016): Update of Age and sex specific Natural mortality of the blue shark (*Prionace glauca*) in the North Pacific Ocean. ISC Shark Working Group Workshop. ISC document ISC/16/SHARKWG-1/06.

Serena, F., A.J. Abella, F. Bargnesi, M. Barone, F. Colloca, F. Ferretti, F. Fiorentino, J. Jenrette & S. Moro (2020): Species diversity, taxonomy and distribution of Chondrichthyes in the Mediterranean and Black Sea, The European Zoological Journal, 87(1), 497-536. DOI: 10.1080/24750263.2020.1805518.

Silva, A.A., H.M. Silva & K. Erzini (1996): Some results on the biology of the blue shark, *Prionace glauca*, in the North Atlantic based on data from a research cruise of the R/V Arquipelago in Azorean waters: A summary paper. In: Arquipélago: Life and Marine Sciences. Departamento de oceanografia e Pescas da Universidade dos Açores.

Simpfendorfer, C.A., R.B. McAuley, J. Chidlow & P. Unsworth (2002): Validated age and growth of the dusky shark, *Carcharhinus obscurus*, from western Australian waters. Marine and Freshwater Research, 53, 567-573. DOI: 10.1071/MF01131.

Skomal, G.B & L.J. Natanson (2003): Age and growth of the blue shark, *Prionace glauca*, in the North Atlantic Ocean. Collective Volume of Scientific Papers ICCAT, 54(4), 1212-1230. <https://spo.nmfs.noaa.gov/content/age-and-growth-blue-shark-prionace-glaucanorth-atlantic-ocean>.

Stevens, J.D. (1976): First results of shark tagging in the northeast Atlantic, 1972–1975. J. Mar. Biol. Assoc. U.K., 56, 929-937. <https://doi.org/10.1017/S002531540002097X>.

Strasburg, D.W. (1958): Distribution, abundance, and habits of pelagic sharks in the Central Pacific Ocean. Fisheries Bulletin, 138, 335-361. <https://portals.iucn.org/library/node/25218>.

Tanaka, S. (1984): Present status of fisheries biology. In: T. Taniuchi & M. Suyama (Eds.): Elasmobranchs as fishery resources. Jpn. Soc. Sci. Fish. Ser., 49, 46-59.

Taylor, C.C. (1958): Cod growth and temperature. J. Cons. Int. Explor. Mer., 23, 366-370.

Vas, P. (1990): The abundance of the blue shark, *Prionace glauca*, in the western English Channel. Env. Biol. Fish., 29, 209-225. <https://doi.org/10.1007/BF00002221>.

Von Bertalanffy, L. (1938): A quantitative theory of organic growth (Inquires on growth laws II). Human Biol., 10, 181-213.