
| | | | |
|---|---|---|---|
| **CHAPTER 2.1.10.10: WAHOO** | | **AUTHORS: TRAVASSOS, P., MARTINS, K., BELTRÃO, T. (UFRPE)** | **LAST UPDATE: JUNE 2021 Original: English** |

**2.1.10.10: Description of Wahoo (WAH)**

## 1. Names

### *1.a Classification and taxonomy*

**Species name**: *Acanthocybium solandri* (Cuvier, 1832).
**ICCAT species code**: WAH
**ICCAT names**: Wahoo (English), Thazard-bâtard (French), Peto (Spanish)

According to FAO (1983), WoRMS (2021), and ITIS (2021) reports, the wahoo is classified as follows:

- Phylum: Chordata
- Subphylum: Vertebrata
- Superclass: Gnathostomata
- Class: Osteichthyes
- Subclass: Actinopterygii
- Order: Perciformes
- Suborder: Scombroidei
- Family: Scombridae
- Genus: *Acanthocybium*
- Species: *Acanthocybium solandri*

### *1.b Common names*

List of vernacular names used according to ICCAT, FAO and Froese and Pauly (2021). The list is not exhaustive, and some local names might not be included.

**Australia:** Wahoo
**Azores Is.:** Cavala da índia
**Barbados:** King Fish, Wahoo
**Brazil:** Cavala empinge, Cavala wahoo
**Cabo Verde:** Serra da Índia
**China:** 棘鰆
**Chinese Taipei:** 棘鰆
**Colombia:** Peto, Sierra, Sierra canalera, Wahoo
**Cuba:** Peto
**Denmark:** Wahoo
**Dominican Republic:** Peto
**Ecuador:** Peje sierra
**Fiji:** Walu ni bogi
**Galapagos Is.:** Guaho
**Hawaii:** Ono
**Martinique:** Thazard raité
**Mexico:** Peto
**Mozambique:** Cavala gigante
**New Zealand:** Wahoo
**Pacific Islands Trust Territories:** Palau: Keskas, Mersad; Tobi: Yar

**Panama:** Guajú
**Papua New Guinea:** Wahoo
**Philippines:** Tangige
**Poland:** Solandra
**Polynesia:** Paere, Rorora
**Portugal:** Serra da India
**Puerto Rico:** Peto
**Russia:** Korolevskaya makrel
**Sao Tome Princ.:** Peixe fumo
**South Africa:** Wahoo
**Sweden:** Wahoo
**Trinidad & Tobago:** Malata kingfish
**United States:** Wahoo
**Venezuela:** Peto, Sierra

## 2. Identification

### Characteristics of *Acanthocybium solandri*

Wahoo is an oceanic epipelagic fish that can reach a maximum fork length of 210 cm. The heaviest specimen ever caught was 83.5 kg in Cabo San Lucas, Baja California, in 2005 (FAO, 2016). Most individuals range from 100 to 170 cm fork length in fisheries, but size can change according to latitude and hence temperature.

***Colour**:*

Wahoo have a metallic blue to iridescent bluish green coloration on the back. The main characteristic are the 24 to 30 cobalt-blue vertical bars all along the body. The belly and lower parts are silver (**Figure 1**).

**Figure 1.** Adult wahoo (Fonte: Gray Taxidermy, 2021).

***External**:*

- Body fusiform, very elongated and slightly laterally compressed.
- Snout length equally proportional to the rest of the head.
- Teeth strong, triangular, compressed, and finely serrate. Gill rakers absent.
- Two dorsal fins, the first with 23 to 27 spines. The second fin is smaller, presenting 12 to 16 rays, followed by 8 or 9 finlets.
- Anal fin positioned below the second dorsal fin, with 12 to 14 rays followed by 9 finlets.
- Abruptly curved single lateral line in the middle portion of the first dorsal fin.

***Internal***:

- 62 to 64 vertebrates (30 to 32 precaudal; 31 to 33 caudal).
- Swim bladder present.

## 3. Distribution and population ecology

### *3.a Geographical distribution*

*Acanthocybium solandri* is globally distributed in tropical and subtropical waters of the Pacific, Indian, and Atlantic oceans, including the Caribbean and Mediterranean seas (Collette and Nauen, 1983). In the Atlantic Ocean, wahoo is most widely distributed between the latitudes 45ºN and 45ºS from Nova Scotia, Canada, to southern Brazil/Uruguay (west side) and Namibia/South Africa (east side). The largest probabilities of occurrence are observed in the tropical region of the Atlantic Ocean (**Figure 2**).

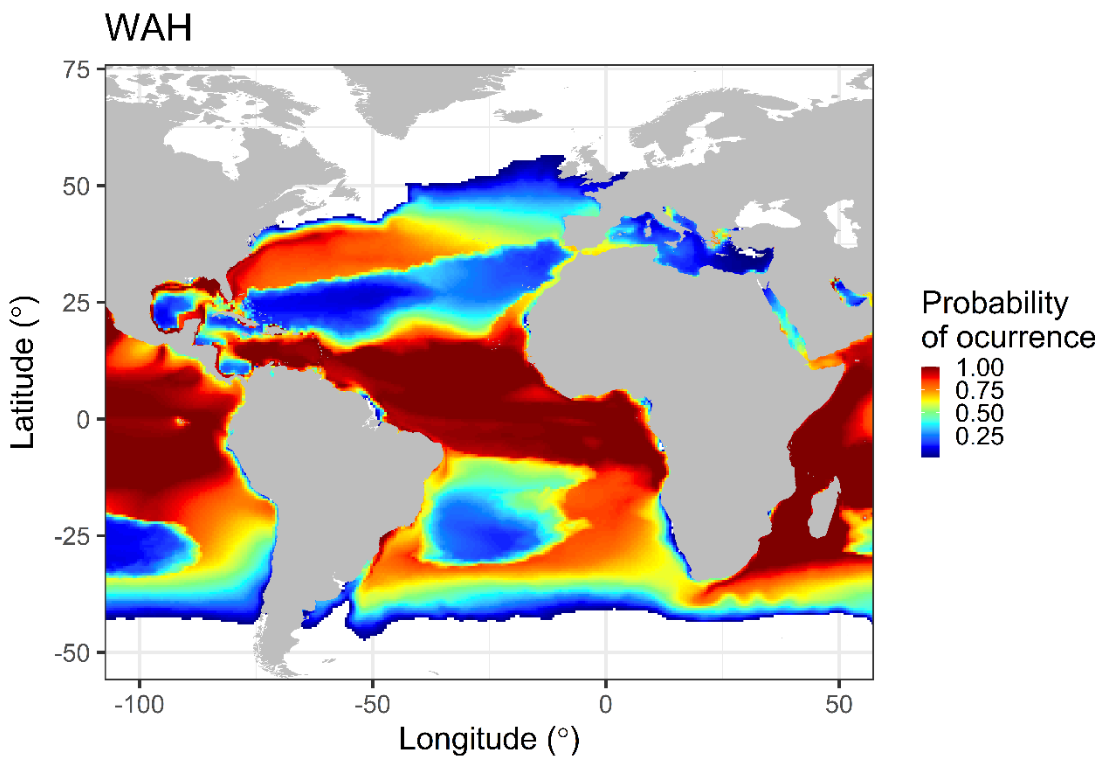


**Figure 2**. Native spatial distribution map for wahoo based on data available on aquamaps.org website. Distribution range colours indicate degree of probabilities of occurrence.

### *3.b Habitat preferences*

Wahoo is an oceanic epipelagic fish, frequently solitary or forming small aggregations rather than compact schools. Usually, the specie occupies waters in the upper mixed layer above the thermocline, in oceanic regions where sea surface temperatures range from 20 and 30ºC (Collette and Nauen, 1983). Research using electronic tagging has confirmed this optimal habitat of the species. In a study conducted off the coast Baja California (Mexico), the depth distribution and temperature preferences of wahoo were determined using archival tags. The results showed a predominant distribution within the upper mixed layer, since the species spent 99.2% of the daytime and 97.9% of night above the thermocline. The temperature values experienced by wahoo ranged from 11.1 to 27.9ºC, with an average of 25.0 ± 1.1C (Sepulveda *et al.*, 2011). In the Eastern coast of Florida/USA, four wahoo were tagged with pop-up satellite archival tags (Theisen *et al*., 2012). The results showed that the fishes spent >90 % of their time in water <200 m, and >90 % of their time in waters between 17.5 and 27.5ºC. A recently published study on the biology and environmental preferences of wahoo in the Western and Central Pacific Ocean has shown that the optimal swimming depth and water temperature range between 70 and 110 m and 23.1 and 24ºC, respectively (Gao *et al*., 2020).

### *3.c Migrations*

Little is known about wahoo movements and migration patterns. Electronic tagging technologies show that wahoo from Eastern Florida/USA display large movements over periods of 1-3 months, probably in association with the Gulf Stream (Theisen *et al*., 2007). In this same area, research conducted using pop-up satellite archival tags showed that straight-line distances between tag deployment and pop-off positions ranged from 162.5 to 1,960.0 km, following a north-northeast direction, also in movements possibly associated to the Gulf Stream (Theisen *et al*., 2012). In the Northeastern Pacific Ocean (Baja California coast), wahoo apparently showed restricted movement based on archival tagging and recapture studies, showing a net movement of less than 20 km after 68 days (Sepulveda *et al*., 2011).

## 4. Biology

### *4.a Growth*

Wahoo is a fast-growing species, especially in the first year, when it can reach about 100 cm FL. This species probably has a short lifespan of 5 or 6 years (Oxenford *et al*., 2003), although some authors estimate a maximum of up to 10 years (Kishore and Chin, 2001; McBride *et al.,* 2008). Studies reported females as the largest individuals captured.

However, there is still an important gap regarding studies on the growth of wahoo in the Atlantic Ocean. Parameters of the von Bertalanffy growth equation are only available for the northwestern area (Table 1).

The estimated values for asymptotic length ($L\infty$) ranged from 149.1 cm to 215.1 cm FL, for instantaneous growth coefficient (k) between 0.152 and 0.381 year$^{-1}$, and a theoretical age at length=0 (t0), from -3.67 to -1.54 (**Table 1**) (Zischke, 2012).

**Table 1.** Growth parameters, fork length range and longevity for wahoo estimated using various analysis methods in studies conducted in the Atlantic Ocean.

| Statistical and stock areas | Authors | Aging method | Analysis type | Fork length range (mm) | Longevity (years) | Von Bertalanffy growth parameters | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $L\infty$ (mm) | K (year−1) | $t_0$ |
| NW | McBride et al. (2008) | Sectioned otoliths | Annual increments | 628-1956 | 9.3 | 1701 | 0.381 | -1.63 |
| NW | Hogarth (1976) | Whole otoliths | Annual increments | 720-1982 | 5 | 2151 | 0.152 | -3.67 |
| NW | Kishore and Chin (2001) | Whole otoliths | Annual increments | 850-1650 | 10 | 1491 | 0.340 | -1.54 |
| NW | Murray and Joseph (1996) | Length Frequencies | ELEFAN | 425-1525 | - | 1566-1610 | 0.31-0.37 | - |
| NW | Murray and Sarvay (1987) | Length Frequencies | ELEFAN | 350-1550 | - | 1580-1590 | 0.34-0.37 | - |

### *4.b Length-weight relationship*

Concerning the length-weight relationship, there is a considerable amount of information available for several geographical areas in the Atlantic Ocean, with the exception of the southeastern sector (**Table 2**).

**Table 2.** Published wahoo length-weight relationship (TL = Total Length – cm; FL = Fork Length – cm; W = Round Weight – Kg).

| Equation | n | Length range (cm) | Sex | Location | Area | Reference |
|---|---|---|---|---|---|---|
| $W = 1.544 \times 10^{-6} \times FL^{3.294}$ | 746 | 72.0-198.2 | Both | Florida/USA | NW | Hogarth, 1976 |
| $W = 1.845 \times 10^{-6} \times TL^{3.218}$ | 795 | | Both | North Carolina/USA | NW | Hogarth, 1976 |
| $W = 1.517 \times 10^{-6} \times TL^{3.247}$ | 32 | | Both | Maryland/USA | NW | Hogarth, 1976 |
| $W = 0.446 \times 10^{-6} \times TL^{3.502}$ | 72 | | Both | Bermuda | NW | Hogarth, 1976 |
| $W = 2.749 \times 10^{-2} \times FL^{2.722}$ | 417 | 101.0-179.0 | Both | Canary Island/Spain | NE | Santana *et al*., 1993 |
| $W = 8.9 \times 10^{-8} \times FL^{3.862}$ | 391 | 85.0-165.0 | Both | Trinidad & Tobago | NW | Kishore and Chin, 2001 |
| $W = 1.6 \times 10^{-3} \times FL^{3.275}$ | 43 | 82.6-176.0 | Both | Bahia/Brazil | SW | Frota *et al*., 2004 |
| $W = 2.04 \times 10^{-6} \times FL^{3.089}$ | 164 | 99.0-185.0 | Both | G. Mexico-Caribbean | NW | Beerkircher, 2005 |
| $W = 6.1 \times 10^{-10} \times FL^{3.3298}$ | 398 | 62.8-195.6 | Both+Unidentified | Florida/USA-Bahamas | NW | McBride *et al*., 2008 |
| $W = 2.03141 \times 10^{-6} \times FL^{2.71835}$ | 1.440 | 100.0-180.0 | Both | Canary Island/Spain | NE | Pascual-Alayón *et al.,* 2019 |

Some conversion factors of different biometric measurements are available below (**Table 3**).

**Table 3.** Conversion factors of different biometric measurements of wahoo.

| Area | Location | Relationship (units) | Sex | Sample Size | Equation | Reference |
|---|---|---|---|---|---|---|
| Southeastern Caribbean | St. Lucia | Length-gutted weight (Wt in g, L in mm) | All | 195 | $Wt = 1.039 \times 10^{-6} \times TL^{3.206}$ | Murray, 1989; |
| | | | | 36 | $Wt = 2.991 \times 10^{-6} \times FL^{3.072}$ | Murray, 1999 |
| | | | | ? | $Wt = 4.06 \times 10^{-6} \times FL^{3.028}$ | George *et al.*, 2001 |
| | | Length – length (mm) | All | 75 | $FL = 1.086 + 0.950\ TL$ | Murray, 1989; Murray, 1999 |
| | | Length-sagittal radius (mm) | All | 9 | $TL = 15.56\ S_R^{1.929}$ | Murray, 1989 |
| North Caribbean | | Length-dorsal spine annuli(mm) | All | 22 | $FL - 748.406 + 214.69\ SP_A$ | Franks *et al*., 2000 |
| Gulf of Mexico | Northern | length-dorsal spine length(mm) | All | 59 | $FL = 452.736 + I\ 2.852\ SP_L$ | Franks *et al*., 2000 |
| | | Length-dorsal spine wt (L in mm, Wt in g) | All | 63 | $FL = 862.358 + 704.691\ SP_W$ | |
| | | Length-dorsal spine diameter (mm) | All | 63 | $FL = 365.683 + 277.002$ | |
| | | Length-dorsal spine annuli(min) | All | 63 | $FL = 735.151 + 186.01\ SP_A$ | |
| | | Dorsal spine diameter-dorsal spine annuli (mm) | All | 55 | $SP_D = 1.610 + 0.561\ SP_A$ | |
| Eastern USA | North Carolina | Length-length (cm) | All | 795 | $TL = 2.452 + 1.016\ FL$ | Hogarth, 1976 |
| | | Length-caudal fin span (cm) | All | 795 | $TL = 2.832 + 1.016\ CF$ | |
| | | Length-girth (cm) | All | 795 | $TL = 0.656 + 1.020\ G$ | |
| | | Weight-girth (Wt in kg, L in cm) | All | 795 | $Wt = 16.765 + 0.644\ G$ | |
| | | Length-sagittal radios(mm) | - | - | $TL = 34. l4 + 0.599\ S_R$ | |

Adapted from Oxenford *et al.*, 2003.
TL = Total Length; FL = Fork Length; $S_R$ =sagittal radius; $SP_A$= dorsal spine annuli; $SP_L$ =dorsal spine length; $SP_W$ = dorsal spine weight; $SP_D$ = dorsal spine diameter; G = Girth; CF = Caudal fin.

### *4.c Reproduction*

- *Spawning*

There are few studies on the reproductive biology of wahoo in the Atlantic Ocean, despite its economic importance in some areas and countries. In general, the species is capable of spawning all year-round in the tropics, although reproduction activity usually occurs during the summer, in both hemispheres. Wahoo exhibits high dispersal characteristics with production of buoyant eggs and post larvae, with spawning occurring in oceanic and neritic waters, at depths of up to 200 m (Brown-Peterson *et al*., 2000; Zischke, 2012).

In the northwest area, it has been observed that spawning takes place in the summer (June-August), in different locations such as the coast of North Carolina, Florida, northern Gulf of Mexico, and Bahamas (Hogarth, 1976; Brown-Peterson *et al.,* 2000; Jenkins and McBride, 2009). The spawning occurs multiple times throughout the reproductive season with the species performing an average of one spawning per week (Brown-Peterson *et al.,* 2000; Jenkins and McBride, 2009). These authors also observed the occurrence of mature-inactive females (13.0-13.6%) during the reproductive season, suggesting that these fish were skip spawning.

In the southwest area, a spawning peak for females occurs between April and May, while for males it occurs between April and June around the St Peter and St Paul Archipelago (Brazil) (Viana *et al*., 2013).

- *Maturity*

Wahoo exhibits early sexual maturity, which occurs before the age of one, with values ranging from 0.64 (Jenkins and McBride, 2009) to 2.0 (Brown-Peterson *et al.,* 2000). Different values of the size of first sexual maturation in the Atlantic were estimated. The size at 50% maturity ($L_{50}$) for female fish caught in the Northwest Atlantic varied between studies conducted, being 97.0 cm FL in North Carolina (Hogarth, 1976), and 95.0 cm FL in Bermuda (SAFMC 1998 *apud* Oxenford *et al.,* 2003), 92.5 cm FL in Florida's east coast and northern Bahamas (Jenkins and McBride, 2009); 102.0 cm FL in the northern Gulf of Mexico (Brown-Peterson et al., 2000). Recently, a new paper estimated the length and age at 50% sexual maturity for female wahoo in the northern Gulf of Mexico at 101.5 cm FL and 0.92 years, respectively (Lang *et al*., 2020).

For the equatorial Atlantic region, a first maturation furcal length of 110 cm was found for females (Viana *et al*., 2013). In relation to males, most authors found an $L_{50}$ of 102 furcal length cm (Brown-Peterson *et al*., 2000; SAFMC 1998 *apud* Oxenford *et al*., 2003; Viana *et al*., 2013), while Hogarth (1976) estimated a total length of 101 cm.

- *Sex ratio*

A balanced ratio between males and females was reported for most of the research conducted by different authors, with values close to 1:1 (Brown-Peterson *et al.,* 2000; Oxenford *et al.,* 2003; Jenkins and McBride, 2009; Viana *et al*., 2013). However, Hogarth (1976) found a female-biased ratio of 3:1, suggesting that this is probably a result of: "(i) different migration patterns between the sexes, (ii) greater catchability of females resulting from differences between the sexes in preferred habitat, or (iii) a shorter lifespan in males such that there are few males in the size range taken by the fishery."

- *Fecundity*

The species has asynchronous oocyte development and a batch spawning pattern, with hydrated oocyte diameters ranging from 700-900 µm (Brown-Peterson *et al*., 2000). These same authors observed an apparent increase in batch fecundity with size and age, a result also observed by Jenkins and McBride (2009).

Wahoo fecundity in the Atlantic Ocean was estimated by different methods and for a limited number of individuals in most published research, and therefore there is a strong variation in the results obtained (Oxenford *et al.,* 2003).

In the Northwest area, estimated fecundity for the North Carolina coast ranged from 0.56 million to 45.340.000 eggs (n = 87 fishes with total length between 103 to 180 cm) (Hogarth, 1976). Using this same method in the Northwestern central Atlantic, Collette and Nauen (1983) estimated a fecundity of 6 million eggs in a single mature ovary (fish of 131 cm FL). In the northern Gulf of Mexico, a mean value of around 1.1 million eggs was estimated (n = 3 fishes with fork length between 103 to 163 cm (Brown-Peterson *et al.,* 2000) based on the number of hydrated oocytes in mature ovaries. On the east coast of Florida and northern Bahamas, wahoo batch fecundity varied between 0.44 and 1.67 million eggs (n = 3 fishes with FL from 109.6 to 144.5 cm) (Jenkins and McBride, 2009).

In the Southwest area, a study carried out in the St Peter and St Paul Archipelago (Brazil), the batch fecundity estimate ranged from 287,040 to 2,494.512 oocytes, in females with fork length of 121 cm (gonads weighing 130 g) and 150 cm (gonads weighing 612 g) respectively. Mean relative fecundity was 1,317.235 oocytes.

***4.d First life stages***

- *Eggs and larvae*

Eggs are pelagic. Yolk sac pigmentation presents patches of melanophores on both sides of developing embryos and along its dorsal portion. A clear oil globe is located at the end of embryos' caudal and it possesses two dense concentrations of melanophores (Hyde *et al.,* 2005). The hatch size is 2.5 mm. The larvae present pigmentations on the jaw tips, fore- and midbrain, nasal area, ventral spot on tail, over gut, spot under second dorsal (Richards, 2005).

- *Recruitment*

No information is available on this topic.

***4.e Diet***

Wahoo is a generalist top predator species, with a diet generally composed by fish, cephalopods and small crustaceans. Due to an opportunistic feeding strategy, the items in the diet change according to the variety and abundance of prey available in the environment (Franks *et al*., 2007). They feed near the surface and may make short dives to capture prey as indicated by vertical migration behavior (Sepulveda et al., 2011; Theisen and Baldwin, 2012). In the western central Atlantic, wahoo was primarily piscivorous, with 70% of food items consisted by fish from the epipelagic community, and cephalopods consumed secondarily (Oxenford *et al.,* 2003). In the eastern Pacific, squids were the most important component of the diet (Mendoza-Ávila *et al.*, 2016). Adaptive feeding behavior has also been verified by the species in the Indian Ocean, whose diet can vary seasonally, being mainly piscivorous in February, and alternating to a predominance of cephalopods in October (Malone *et al.,* 2011). In the Equatorial West Atlantic region, the Saint Peter and Saint Paul Archipelago, a remarkable trophic activity focusing on Exocoetidae fish (*Cypselurus cyanopterus*) has been observed (Vaske Jr *et al*., 2004; Albuquerque *et al*., 2019). Recently, the opportunistic piscivorous habit of wahoo has been demonstrated by a strong presence of Exocoetidae and Diodontidae in their diet, and a tendency to specialize in the use of available resources in the region of the Fernando de Noronha Archipelago (Martins, 2020). These trophic mechanisms help minimize competition, since the species feeds on different prey available, coexisting with other sympatric species in the oceanic pelagic environment.

***4.f Physiology***

Active and fast-swimming species capable of jumping out of the water. Similar to other members of the family Scombridae, it has specializations (rigid structures) on the gills that prevent lamellar deformation during rapid water flow. Such structures have the function of maintaining rigidity during rapid swimming, allowing for the proper $O_2$ uptake necessary for high aerobic performance (Wegner *et al.,* 2006). Large individuals are able to reach a swimming speed of about 45 km/h, with most of the propulsion generated by the caudal fin (Fierstine and Walters, 1968). They prefer temperatures between 20 and 30ºC, occupying almost exclusively epipelagic waters in the upper mixed layer above the thermocline at depths below 50 m (Zischke, 2012).

***4.g Behaviour***

Wahoo is a commonly solitary species, but capable of forming small aggregations especially around floating objects, fish attracting devices (FADs), seamounts and islands (Collette and Nauen, 1983). However, it is still unknown if the species exhibits site fidelity (Sepulveda *et al*., 2011). It is present all year-round in the Caribbean and Gulf of Mexico, although it may exhibit seasonal behavior in different locations, such as in temperate waters of the North Atlantic (Oxenford *et al*., 2003). This species exhibits dispersal characteristics with the production of floating eggs and post larvae, whose spawning occurs in the vicinity of open ocean currents in the Atlantic and Pacific Oceans (Brown-Peterson *et al*., 2000, Zischke 2012). The use of PSATs, one type of electronic devices, have revealed extensive movements of wahoo (100-1000 km) during 1–3-month periods off East Florida, possibly in association with the Gulf Stream (Theisen, 2007). However, in the eastern Pacific Ocean, restricted movement of the species has been observed in specimens tagged and recaptured after periods up to 68 days, revealing movements of less than 20 km (Sepulveda *et al*., 2011).

### *4.h Natural mortality*

The natural mortality (M) of wahoo was estimated only for the Northwest area in the Atlantic Ocean. Around St Lucia (Caribbean Sea), Murray and Sarvay (1987) have estimated the natural mortality of wahoo to be M = 0.56-0.58 $year^{-1}$ (years 1982-1983) and Murray and Joseph (1996) to be M = 0.49-0.54-0.54 $year^{-1}$ (years 1988-1989-1990).

### *4.i Populations/Stock structure*

Due to the lack of information that could define the spatial structure of the WAH population in the Atlantic Ocean, ICCAT currently considers five statistical/stock areas for catch reporting, assessment, and management purposes for *Acanthocybium solandri*: Mediterranean Sea (Med), Northeast Atlantic (NE), Northwest Atlantic (NW), Southeast Atlantic (SE) and Southwest Atlantic (SW).

## 5. Description of fisheries

### *5.a Catch composition*

Analyses carried out on the pelagic fisheries in St. Lucia, Northwest Atlantic area (Murray and Joseph, 1996) showed, from 1984 to 1990, a downward trend in wahoo catches, with the lowest catch occurring in 1989.

Considering the total annual catches (Atlantic and Mediterranean), four phases can be identified over the period 1968-2019 with recorded landings (**Figure 3**). The first phase, between 1968-1980, with low catches, ranging around an average of 372 t and derived mainly from the Northwest Atlantic. The second phase, between 1981-2011 was characterized by increases in catches to values around the average of 2,176 t. Up until 1999, an important part of the catches had no area identified (unknown), with the remainder coming from the Northwest and Southeast areas, with this last having a small participation. From 2000 until the end of this phase (2011), an increasing contribution of catches from other areas is observed, while catches from unknown areas decreased significantly. The third phase shows a rapid and high growth in catches, ranging from 4,316 t in 2012 to 17,315 t in 2016. This peak had an important participation from catches of the Northeast area, with 14,214 t of the total reported. The last phase is characterized by the start of declines in catches, from 6,871 t in 2017 to 4,711 t in 2019, with the Northeast area having the largest contribution in all three years.

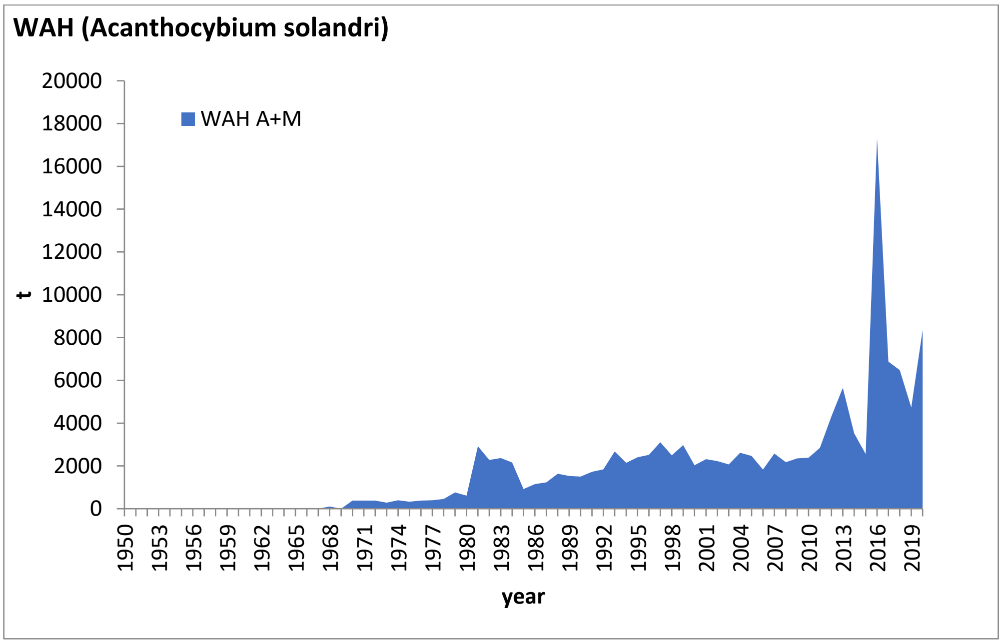


**Figure 3**. Total catches (t) of wahoo (*Acanthocybium solandri*) in the ICCAT database by year between 1950 and 2020.

Wahoo is caught through different gear types along the Atlantic Ocean and Mediterranean Sea, including baitboat (BB), rod and reels (RR), handlines (HL), longlines (LL), gillnets (GN), purse seines (PS), and others. These different methods contribute in many different ways to the catches made by statistical/stock areas (**Figure 4**).

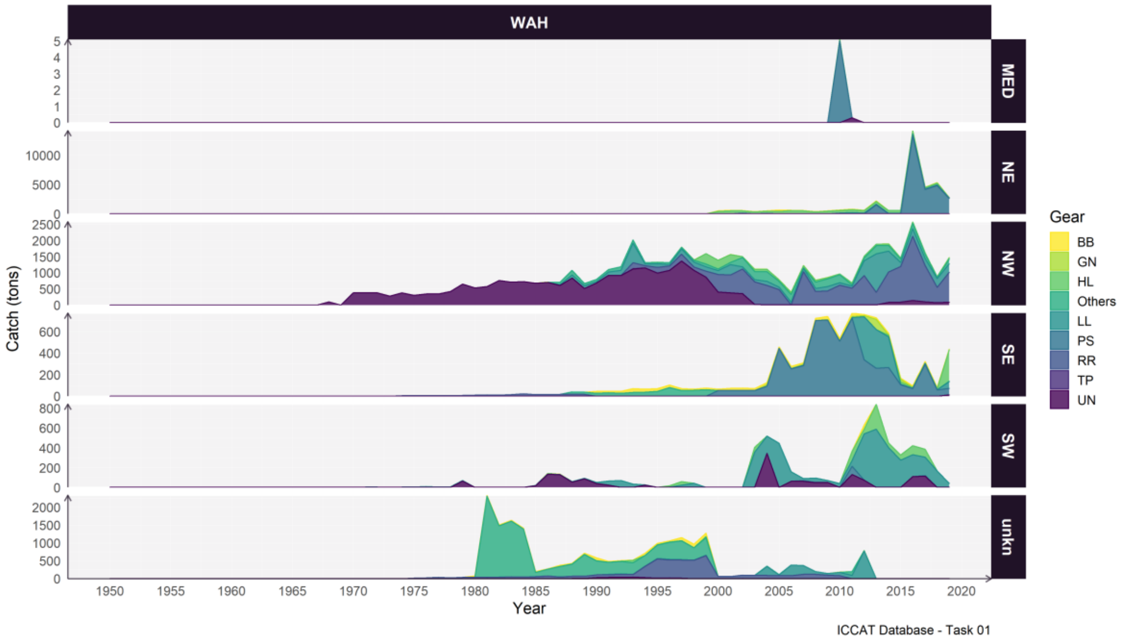


**Figure 4.** Catch distribution of wahoo in the Atlantic Ocean from 1950 to 2019 by statistical/stock areas and fishing gear. UN: Unknown. TP: traps. RR: rod and reel. PS: purse seine. LL: longline. HL: handline. GN: gillnets. BB: baitboats. Others includes: trawl (TW), trolling (TR), haul seine (HS), trammel net (TN), sport (SP), tended line (TL), and harpoon (HP).

### *5.b Length composition*

Based on ICCAT Task 2/size data, wahoo size data are available for all areas except the Mediterranean Sea (**Figure 5**). The largest amount of size information (fork length) is in the North Atlantic. In the Northwest Atlantic, a wider range of sizes was observed, with specimens caught showing length frequency distribution between the 90-100 to 140-150 cm length classes. In the Northeast area, fishes with sizes below 110 cm were not reported. In the Southeast area, only fishes smaller than 110 cm and larger than 130 cm were observed, while in the Southwest area, catches of wahoo were recorded in the 110-120 cm and 130-140 cm length classes.

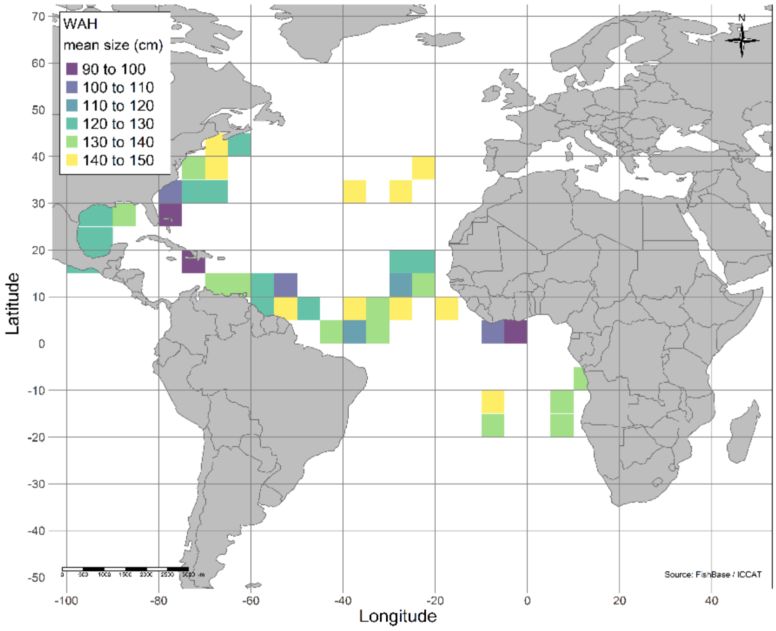


**Figure 5.** Spatial distribution of mean size of wahoo by length class between 1982 and 2019.

The annual variation of mean lengths for the 1982-2019 period in the Northeast area shows a small decrease at the beginning of the series, from 145.3 cm (SD = 9.19) in 1986 to 134.9 cm FL (SD = 19.56) in 1989. Thereafter the values oscillate around the mean of 128.5 (SD = 15.29) until the end of the period in 2019. Information regarding the recruitment of wahoo in the fishery is very scarce for the Atlantic Ocean. From 1984 to 1990, in Northwest Atlantic, in St. Lucia, a decrease in the length at first capture (the length at which the catch propensity is 0.5) was observed. In this same area, according to the ICCAT Task 2 size data, a slight decreasing tendency was observed in the initial period (1982-2002), from which time the values oscillate around the average of 117.2 cm (SD = 21.44). In the Southeastern area, in contrast, an increasing trend in wahoo catch sizes was observed, with mean values ranging from 99.7 cm (SD = 15.87) in 2005 to 136.1 cm (SD = 10.97). Although few data are available for the southwestern area, higher values were observed in 1986 (mean of 132.5 – SD = 9.42) and 1987 (mean of 142.3 – SD = 6.78), while in 2009 the mean size was 114.1 cm (SD = 11.04), possibly indicating a downward trend (**Figure 6**).

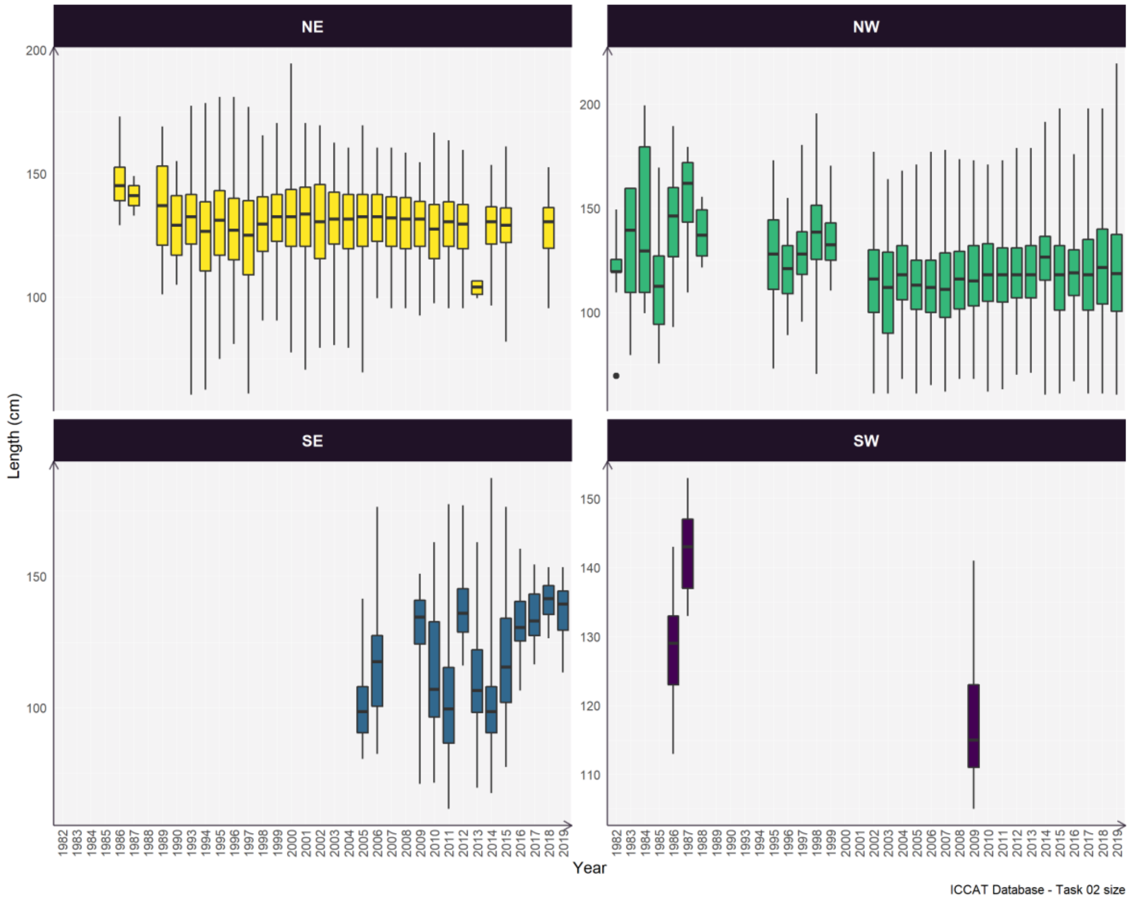


**Figure 6**. Annual variation of the furcal length of wahoo in the Atlantic Ocean over the period 1982-2019.

**6. Stock assessment**

Based on the results obtained in the semi-quantitative risk assessment (Productivity and Susceptibility Analysis, PSA) for some small tuna species, northern and southern Atlantic wahoo was classified as low vulnerability and high vulnerability, respectively (Lucena-Frédou *et al.*, 2017a, b).

In recent years, a quantitative assessment has been conducted for this species using length-based, data-limited methods such as length-based spawning potential ratio (LBSPR) and Length-based integrated mixed effects (LIME) (Pons *et al*., 2019). In the Northwest Atlantic, LBSPR and LIME results indicated that this stock is overfished. Meanwhile, in the Northeast Atlantic, although the results have showed some evidence of overfishing, the signals obtained from the two methods were contrasting (Pons *et al*., 2019). In a complementary work, Pons *et al.* (2019) assessed some small tuna stocks in the Atlantic Ocean using catch-based models (DBSRA and SSS) and the integrated version of LIME (LIME_Catch). The results obtained for the northwest stock of wahoo showed that this stock might be overfished (Pons *et al*., 2020).

Kindong *et al.* (2020) also carried out a quantitative assessment using data-limit methods for northeastern wahoo only. Through the LBB model, the authors observed that this stock is not being overfished or experiencing overfishing. These authors also observed that the Lc/Lc_opt ratio showed a value below unity, indicating fishing of small specimens at levels of concern.

To date, no quantitative assessment has been conducted for southwestern wahoo stock.

## 7. Bibliography


Albuquerque, F.V., Navia, A.F., Vaske, T., Crespo, O., hazin, F.H.V. (2019). Trophic ecology of Albuquerque, F.V., Navia, A.F., Vaske, T., Crespo, O., Hazin, F.H.V. (2019). Trophic ecology of large pelagic fish in the Saint Peter and Saint Paul Archipelago, Brazil. Marine and Freshwater Research, 70 (10), pp. 1402-1418.

Beerkircher, L. R. (2005). Length to Weight conversions for Wahoo, *Acanthocybium solandri*, in the Northwest Atlantic. Collective Volume of Scientific Papers of ICCAT, 58, pp. 1616-1619.

Brown-Peterson, N.J, Franks, J.S, Burke, A.M. (2000). Preliminary observations on the reproductive biology of wahoo, *Acanthocybium solandri*, from the northern Gulf of Mexico and Bimini, Bahamas. Proc. Gulf Caribb. Fish. Inst. 51, pp. 414-427.

Collette, B.B. and Nauen C.E. (1983). FAO species catalogue Scombridaes of the World An annotated and llustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fish. Synop. 2, pp. 125-137.

FAO (1983). FAO species catalogue. Vol.2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. Food and Agriculture Organization of the United Nations, Rome, 137 p.

FAO (2016). The living marine resources of the East ern Central Atlantic. Volume 4: Bony fishes part 2 (Perciformes to Tetradontiformes) and Sea turtles. Species Identification Guide for Fishery Purposes. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Rome. pp. 2343–3124.

Fierstine, H.L. and Walters, V. (1968). Studies in locomotion and anatomy of scombroid fishes. Biological Sciences, 6, pp. 4, January 18.

Franks, J.S., Brown-Peterson, N.J., Griggs, M.S., Garber, N.M., Warren, J.R. and Larsen, K.M. (2000). Potential of the first dorsal fin spine for estimating the age of wahoo, *Acanthocybium solandri*, from the northern Gulf of Mexico, with comments on specimens from Bimini, Bahamas. Proceedings of the Gulf and Caribbean Fisheries Institute 51, pp. 428-440.

Franks, J. S., Hoffmayer, E. R., Ballard, J. R., Garber, N. M., & Garber, A. F. (2007). Diet of wahoo, Acanthocybium *solandri*, from the Northcentral Gulf of Mexico. *Proceedings of the 60th Gulf and Caribbean Fisheries Institute*, pp. 353-362.

Frota, L. O.; COSTA, P. A. S.; Braga, A. C. (2004). Length-weight relationships of marine fishes from the central Brazilian coast. NAGA, WorldFish Center Quarterly, 27 (1-2), pp. 20-26.

Froese, R. and D. Pauly, (2021). FishBase. World Wide Web electronic publication. www.fishbase.org, version (02/2021). Editors. https://www.fishbase.se/search.php (Accessed on 25 May 2021).

Gao, C., Tian, T., Kindong, R., Dai, X. (2020). Biology and Environmental Preferences of Wahoo, *Acanthocybium solandri* (Cuvier, 1832), in the Western and Central Pacific Ocean (WCPO). J. Mar. Sci. Eng., 8, 184; doi:10.3390/jmse8030184, 13 p.

George, S. Singh-Renton, S. and Lauckner, B. (2001). Assessment of wahoo (*Acanthocybium solandri*) fishery using eastern Caribbean data. In: S. Singh-Renton, ed. Report of the 2000 Caribbean Pelagic and Reef Fisheries Assessment and Management Workshop, June, 5-7, 2000, Hastings, Barbados. CARICOM Fishery Report 9, pp. 25-40.

Hogarth, W.T. (1976). Life history aspects of the wahoo *Acanthocybium solandri* (Cuvier and Valenciennes) from the coast of North Carolina. PhD Thesis, North Carolina State University, Raleigh, NC, USA, 119 p.

Hyde, J.R., Lynn, E., J.R. Humphreys, R., Musyl, M., West, A.P., Vetter, R. (2005) Shipboard identification of fish eggs and larvae by multiplex PCR, and description of fertilized eggs of blue marlin, shortbill spearfish, and wahoo. Mar. Ecol. Prog. Ser., 286, pp. 269-277.

Itis, (2021). Integrated Taxonomic Information System (IT IS) on-line database, www.itis.gov. https://doi.org/10.5066/F7KH0KBK (Acessed on 25 May 2021).

Jenkins, K.L.M. and McBride, R.S. (2009). Reproductive biology of wahoo, *Acanthocybium solandri*, from the Atlantic coast of Florida and the Bahamas. Mar. Fresh. Res. 60 (9), pp. 893- 897.

Kindong, R., Gao, C., Pandong, N.A., MA, Q., Tian, S., Wu, F., SARR, O. (2020). Stock status assessments of five small pelagic species in the Atlantic and Pacific Oceans using the Length-Based Bayesian Estimation (LBB) Method. Front. Mar. Sci. 7:592082. DOI: 10.3389/fmars.2020.592082.

Kishore, R. and Chin, X. (2001). Age and growth studies at the CFRAMP/IMA Regional Age and Growth Laboratory - progress of work done and future approaches. In: S. Singh- Renton, ed. Report of the 2000 Caribbean Pelagic and Reef Fisheries Assessment and Management Workshop, June, 5-7, 2000, Hastings, Barbados. CARl COM Fishery Report 9, pp. 74-89.

Lang, E.T., C.A. Levron, C.D. Marshall, B.J. Falterman. (2020). Life History Metrics of Wahoo (*Acanthocybium solandri*) in the Northern Gulf of Mexico. Gulf and Caribbean Research, 31 (1), pp. 1-7. DOI: https://doi.org/10.18785/gcr.3101.03.

Lucena-Frédou, F., Kell, L., Frédou, T., Gaertner, D., Potier, M., Bach, P., Travassos, P., Hazin, F., Ménard, F. (2017a) Vulnerability of teleosts caught by the pelagic tuna longline fleets in South Atlantic and Western Indian Oceans. Deep–Sea Research Part II, 140: 230–241. DOI: 10.1016/j.dsr2.2016.10.008.

Lucena-Frédou, F., Frédou, T., Ménard, F. (2017b). Preliminary Ecological Risk Assessment of small tunas of the Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 73, pp. 2663–2678.

Malone, M.A., Buck, K.M., Moreno, G., Sancho, G. (2011). Diet of three large pelagic fishes associated with drifting fish aggregating devices (DFADs) in the western equatorial Indian Ocean. Animal Biodiversity and Conservation, 34 (2), pp. 287-294

Martins, K. M. A. B. (2020). Ecologia trófica de peixes pelágicos no arquipélago de Fernando de Noronha, Atlântico Equatorial, Brasil. Master's Dissertation, Federal Rural University of Pernambuco (UFRPE)

Mendoza-Ávila, M., Zavala-Zambrano, G., Galván-Magaña, F., Loor-Andrade, P. (2017). Feeding habits of wahoo (*Acanthocybium solandri*) in the eastern Pacific Ocean. Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom, 97 (7), 1505 p.

McBride, R.S, Richardson, A.K, Maki, K.L. (2008). Age, growth, and mortality of wahoo, *Acanthocybium solandri*, from the Atlantic coast of Florida and the Bahamas. Mar. Fresh. Res. 59, pp. 799-807.

Murray, P.A. (1989). A comparative study of methods for determining mean length-at-age and von Bertalanffy growth parameters for two fish species. M.Phil. Thesis, University of the West Indies, Cave Hill Campus, Barbados, 222 p.

Murray, P.A. (1999). Morphometric relationships in wahoo, *Acanthocybium solandri*, landed in St. Lucia. Proceedings of the Gulf and Caribbean Fisheries Institute 45, pp.552-556

Murray, P.A. and Joseph, W.B. (1996). Trends in the exploitation of the wahoo, *Acanthocybium solandri*, landed in St. Lucia. Proceedings of the Gulf and Caribbean Fisheries Institute, 44, pp. 737–746.

Murray, P.A. and Sarvay, W.B. (1987). Use of ELEFAN programs in the estimation of growth parameters of the wahoo, *Acanthocybium solandri*, caught off St. Lucia, West Indies. Fishbyte, 5, pp. 14–15.

Oxenford, H.A., Murray, P.A., Luckhurst, B.E. (2003). The biology of wahoo (*Acanthocybium solandri*) in the western central Atlantic. Gulf and Caribbean Research, 15 (1), pp. 33-49.

Pascual-Alayón, P.J., Casañas Machin, I., Báez Barrionuevo, J.C, Ramos, Mª L., Abascal, F. J. (2019). The wahoo *Acanthocybium solandri* (Cuvier, 1832) fishery in El Hierro island (Canary Islands, Spain) and biology in the east Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT,.76 (7): 156-168.

Pons, M., Kell, L., Rudd, M.B., Cope, J.M., Fredou, F.L. (2019). Performance of length-based data-limited methods in a multifleet context: application to small tunas, mackerels, and bonitos in the Atlantic Ocean. – ICES Journal of Marine Science. 76, pp. 960–973.

Pons M., Cope J.M., Kell L.T. (2020). Comparing performance of catch-based and length-based stock assessment methods in data-limited fisheries. Canadian Journal of Fisheries and Aquatic Sci, 76 (6), https://doi.org/10.1139/cjfas-2019-0276.

Richards, W.J., (ed.), (2005). Early Stages of Atlantic Fishes: An identification guide for the western central North Atlantic. CRC Press, Taylor and Francis Group, Boca Raton, FL, 2640 p.

SAFMC (1998). Proceedings of the South Atlantic Fishery Management Council dolphin/wahoo workshop, Charleston, SC, USA,May 6-9, 1998, unpag. Apud Oxenford, H. A.; Murray, P. A.; LuckhursT, B. E. (2003). The biology of wahoo (*Acanthocybium solandri*) in the western central Atlantic. Gulf and Caribbean Research, 15 (1), pp. 33-49.

Santana, J.C., Delgado de Molina, A., Ariz, J. (1993). Estimacion de uma ecuacion talla-peso -para *Acanthocybium solandri* (Cuvier, 1832) capturado en la isla de El Hierro (Islas Canarias). Collect. Vol. Sci. Pap. ICCAT, 40(2): 401-405.

Sepulveda, C.A., Aalbers, S.A., Ortega-Garcia, S., Wegner, N.C., Bernal, D. (2011). Depth distribution and temperature preferences of wahoo (*Acanthocybium solandri*) off Baja California Sur, Mexico. Marine Biology, 158 (4), pp. 917-926.

Theisen, T.C., Bowen, B.W., Lanier, W., Baldwin, J.D. (2007). High connectivity on a global scale in the pelagic wahoo, *Acanthocybium solandri* (tuna family Scombridae). Molecular Ecology, 17 (19), pp. 4233-42473.

Theisen, T.C., and Baldwin, J.D. (2012). Movements and depth/temperature distribution of the ectothermic Scombrid, *Acanthocybium solandri* (wahoo), in the western North Atlantic. Marine Biology, 159 (10), pp. 2249-2258.

Vaske JR, T., LessA, R.P., Ribeiro, A.C.B., Nóbrega, M.F., Pereira, A.D.A., Andrade, C.D.P. (2004). A pesca comercial de peixes pelágicos no Arquipélago de São Pedro e São Paulo, Brasil. Tropical Oceanography Online, 36, pp. 47-54.

Viana, D.L, Branco, I.S.L, Fernandes, C.A, Fischer, A.F, Carvalho, F, Travassos, P. (2013) Reproductive biology of the wahoo, *Acanthocybium solandri* (Teleostei: Scombridae) in the Saint Peter and Saint Paul Archipelago, Brazil. Intl J Plant Ani Sci., 1, pp. 049–057.

Zischke, M.T. (2012). A review of the biology, stock structure, fisheries and status of wahoo (*Acanthocybium solandri*), with reference to the Pacific Ocean. Fisheries Research, 119–120 (2012) 13–22.

WegneR, N.C., Sepulveda, C.A., Graham, J.B. (2006). Gill specializations in high-performance pelagic teleosts, with reference to striped marlin (*Tetrapturus audax*) and wahoo (*Acanthocybium solandri*). Bulletin of Marine Science, 79 (3), pp. 747–759.

WoRMS, (2021). World Register of Marine Species. Available from https://www.marinespecies.org at VLIZ. (Accessed on 25 May 2021).