

## Identification of areas with adequate temperature for the culture of cobia in cages along the Brazilian coast

Larissa Neves Simões de Souza Lima<sup>1</sup>, Santiago Hamilton<sup>1</sup>,  
Thales Ramon Queiroz Bezerra<sup>2</sup>, Ronaldo Olivera Cavalli<sup>3</sup>

<sup>1</sup> Universidade Federal Rural de Pernambuco, Departamento de Pesca e Aquicultura, Recife, PE, Brasil. E-mail: larissansimoes@yahoo.com.br (ORCID: 0000-0001-6654-9811); santihamilton@hotmail.com (ORCID: 0000-0002-1886-1074)

<sup>2</sup> Instituto Federal de Pernambuco, Campus Recife, Recife, PE, Brasil. E-mail: thales\_ramon@hotmail.com (ORCID: 0000-0002-3005-8348)

<sup>3</sup> Universidade Federal do Rio Grande, Instituto de Oceanografia, Rio Grande, RS, Brasil. E-mail: ronaldocavalli@gmail.com (ORCID: 0000-0003-3390-6346)

**ABSTRACT:** This study identified regions of the Brazilian coast that present more adequate temperature conditions for the cage culture of cobia (*Rachycentron canadum*). A survey of sea surface temperatures (SST) along the coast (up to the 200 m isobath) used data from the Aqua/NASA satellite. Water temperature classes that affect the development of cobia and may lead to changes in physiological activities, especially related to feed intake, growth, and mortality, were established, according to the literature. Cobia is able to grow at temperatures between 19 and 32 °C, but the range considered optimum for growth was 27–29 °C. The coastal area stretching from eastern Pará to the north of Bahia was considered to have the most suitable temperature conditions for commercial aquaculture of cobia. The coastline encompassing the state of Amapá to the west of Pará, and the whole coast of the southeast region presented SSTs above or below the range considered optimum for the growth of cobia, respectively. In the southern coast of Brazil, the commercial farming of cobia may not be feasible due to the low SST during most of the year.

**Key words:** aquaculture; coastal planning; marine fish farming; sea surface temperature

## Identificação de áreas com temperaturas adequadas para a criação do beijupirá em gaiolas na costa brasileira

**RESUMO:** Este estudo identificou as regiões da costa brasileira que apresentam temperaturas mais adequadas para a aquicultura do beijupirá (*Rachycentron canadum*) em gaiolas. Um levantamento da temperatura da superfície do mar (TSM) ao longo da costa brasileira até a isóbata de 200 m usou dados do satélite Aqua/NASA. As classes de temperatura da água que afetam o desenvolvimento do beijupirá e podem levar a mudanças nas atividades fisiológicas, especialmente em relação à ingestão de alimento, crescimento e mortalidade, foram estabelecidas de acordo com a literatura. O beijupirá apresenta crescimento em temperaturas entre 19 e 32 °C, mas a faixa considerada ótima para o crescimento foi de 27-29 °C. A área costeira que se estende do leste do Pará ao norte da Bahia foi considerada como tendo as condições de temperatura mais adequadas para a aquicultura comercial do beijupirá. O litoral abrangendo o estado do Amapá ao oeste do Pará e toda a costa da região sudeste apresentam temperaturas acima e abaixo do intervalo considerado ótimo para o crescimento do beijupirá, respectivamente. Na costa sul do Brasil, a aquicultura comercial do beijupirá pode não ser viável devido às baixas TSM que ocorrem durante a maior parte do ano.

**Palavras-chave:** aquicultura; planejamento costeiro; piscicultura marinha; temperatura da superfície do mar

## Introduction

Cobia (*Rachycentron canadum*) is a marine fish with huge potential for aquaculture development in tropical areas of the world. Aside its capacity for rapid growth and high quality white flesh, it easily breeds in captivity, has high fecundity, and hatchery and grow-out protocols are readily available (Liao et al., 2004; Nhu et al., 2011; Liao & Leño, 2007). Increased production of cobia in Asia has sparked an interest in several other countries, including Brazil (Hamilton et al., 2013). From the total world aquaculture production of cobia, estimated at 43,107 tons in 2016 (FAO, 2018), the largest share comes from floating cages deployed in protected coastal areas of China, Taiwan and Vietnam (Nhu et al., 2011; FAO, 2018). There is, however, a trend towards production in offshore waters, as there are issues of competition for space with other users, problems with water quality, and oftentimes there is also a negative public perception of environmental and aesthetic impacts (Kapetsky et al., 2013).

Although marine fish culture is in its infancy in Brazil, it is estimated to have one of the largest offshore areas available for cage aquaculture in the world (Kapetsky et al., 2013). In recent years, two offshore farms operated off northeastern Brazil (Hamilton et al., 2013), while smaller scale, near-shore cobia farms operate in the states of Rio de Janeiro and São Paulo (Bezerra et al., 2016; Rombenso et al., 2016).

Among the several criteria that need to be considered to assess the adequacy of a certain area for cage aquaculture (Benetti et al., 2010a), water temperature is by far the primary environmental variable. Temperature is the most important external factor affecting fish development and growth (Brett & Groves, 1979; Baldisserotto, 2013). While land-based aquaculture operations may maximize fish growth through the manipulation of temperature, for cage aquaculture, which is sited in open waters, the choice of adequate areas, in terms of environmental variables, is vital to its success. Thus, the definition of coastal areas where environmental conditions are more favorable for fish growth may support potential investors, and help to channel resources for the sustainable development of cage aquaculture in Brazil. This study, therefore, identified regions along the Brazilian coast that present more adequate conditions, in terms of water temperature, for the commercial culture of cobia in cages.

## Material and Methods

The area considered in this work was the totality of the Brazilian coast. The survey of sea surface temperature (SST) was carried out over a five-year period (2005 to 2009), using spatial and temporal resolutions of 4 km and one month, respectively. Only the area between the baseline of the coast and the 200 m isobath was considered. The SST data was generated from information collected by the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor of the Aqua satellite, which is produced and distributed by the "Jet Propulsion Laboratory/NASA" Physical Oceanography Distributed Active Archive Center, in the data tool "The

PO.DAAC Ocean ESIP Tool - POET," at <http://poet.jpl.nasa.gov/>. Annual SST data were grouped to obtain monthly temperature averages. The months were grouped in four periods, representing the meridional seasons (summer: from January to March; autumn: April to June; winter: July to September; and spring: October to December).

For an analysis directed specifically to cobia aquaculture, a review of the specialized literature concerning the effects of temperature, especially in relation to food intake, growth, and mortality, was carried out.

The results were synthesized on maps produced with the ArcGIS software version 10.1. As Brazil has continental dimensions and regions with distinct climates, the maps were subdivided in the limits of geopolitical regions (north, northeast, southeast and south). In the structure of the geographic information system (GIS), the temperature classes were grouped into categories according to the growth and/or survival of cobia.

Nine water temperature classes were established (Table 1): optimal growth (Class E), moderate growth (Classes C, D, F, and G), slow growth (Classes B and H), and mortality (Classes A and I). The optimum temperature for growth is in the range of 27–29 °C (Class E). Any deviation from this range results in lower food intake and decreased growth. Water temperatures below 16 °C (Class A) and above 37 °C (Class I) are considered to be lethal for cobia (Table 1).

## Results and Discussion

Regardless of season, the mean SST per region ranged from 19.5–28.3 °C, while minimum and maximum SST were 10.5 and 32.2 °C, respectively (Table 2). Mean values of SST were higher in the north and northeast, intermediate in the southeast, and lower in the southern region.

For ectothermic fish species such as cobia, there are temperature ranges that favor development and growth (Baldisserotto, 2013). Growth rates for fish commonly follow a bell-shaped curve, with increasing growth until reaching a maximum at the temperature optimum and then decreasing rapidly with further increase in temperature (Bjornsson et al., 2001). The analysis of the literature (Table 1) indicates that cobia is able to grow at temperatures between 19 and 32 °C, which agrees with the temperature range (16.8–32.0 °C) in which wild individuals are captured by fisheries (Shaffer & Nakamura, 1989).

Based solely on the evidence presented above, it would be reasonable to infer that cobia could be commercially reared in almost the entire Brazilian coast. The only exception would be southern Brazil, where, for most of the coast, the mean SST during winter ranges from 16–19 °C or even below 16 °C (Figures 1A and 1B). In the northern coast of the state of Paraná, however, mean SST in winter remained above 19 °C. On the other hand, the minimum SST in autumn, winter, and spring in this region was estimated at 13.0, 10.5, and 14.6 °C, respectively (Table 2). It is well known that even for a short period of time, water temperatures under 16 °C can lead to the death of cobia (Atwood et al., 2004; Liao et al.,

**Table 1.** Classes of temperature (°C) and their effects on the physiological activity and performance of cobia (*Rachycentron canadum*) according to the specialized literature.

Temperature	Class	Effects	References
< 16	A	Mortality	Atwood et al. (2004), Liao et al. (2004), McDonald & Bumguardner (2010), Miao et al. (2009)
16 – 19	B	Cease feeding, slow growth	Hassler & Rainville (1975), Weirich et al. (2004), Schwarz et al. (2007), Miao et al. (2009), Nhu et al. (2011)
19 – 23	C	Diminished feed intake, reduced growth rate, moderate growth	Weirich et al. (2004), Schwarz et al. (2007), Miao et al. (2009), Sampaio et al. (2011)
23 – 27	D	Reduced appetite, but same efficiency of nutrient absorption and utilization, less energy directed to growth, moderate growth	Benetti et al. (2010b), Sun et al. (2006), Schwarz et al. (2007), Sun & Chen (2014)
27 – 29	E	Maximal efficiency of feed conversion, high survival rate, optimal growth	Benetti et al. (2010b), Sun et al. (2006), Schwarz et al. (2007), Yu & Ueng (2007), Sun & Chen (2009, 2014)
29 – 32	F	Increased feeding rate, but similar feeding efficiency than at 27-29 °C	Sun et al. (2006), Sun & Chen (2014)
32 – 35	G	High metabolism, reduced feeding	Sun et al. (2006), Sun & Chen (2014)
35 – 37	H	Loss of equilibrium, no feeding	Sun et al. (2006), Sun & Chen (2014)
> 37	I	Lethal for juveniles, high mortality	Hassler & Rainville (1975), Miao et al. (2009)

**Table 2.** Mean (minimum/maximum) sea surface temperature (°C) estimated for each season and coastal region of Brazil from 2005 to 2009.

	Summer	Autumn	Winter	Spring
North	27.7 (24.5/30.3)	28.3 (24.7/31.3)	28.0 (25.9/31.2)	28.1 (25.6/32.2)
Northeast	28.3 (24.9/31.2)	28.3 (24.8/31.7)	26.2 (23.8/31.3)	26.8 (24.1/31.3)
Southeast	27.4 (22.7/31.0)	26.0 (19.9/29.8)	23.3 (17.2/26.1)	24.5 (19.5/29.0)
South	24.8 (20.1/30.8)	22.5 (13.0/27.9)	19.5 (10.5/24.1)	21.3 (14.6/27.7)

2004; Miao et al., 2009; McDonald & Bumguardner, 2010), representing an obvious obstacle to the aquaculture of this species in southern Brazil. High mortality of cage-reared cobia was observed in central Taiwan (Miao et al., 2009) and in northern Vietnam (Nhu et al., 2011) when temperatures dropped below 16 °C. In Vietnam, Nhu et al. (2011) reported that water temperature in January and February, 2008 remained below 15 °C for more than five weeks causing a high mortality of cage-reared cobia. These authors also warned that, when low water temperature lasted for more than two weeks, an increased occurrence and virulence of disease outbreaks was observed. Thus, due to the low SST observed for most of the year, the commercial aquaculture of cobia may not be feasible on the coast of southern Brazil.

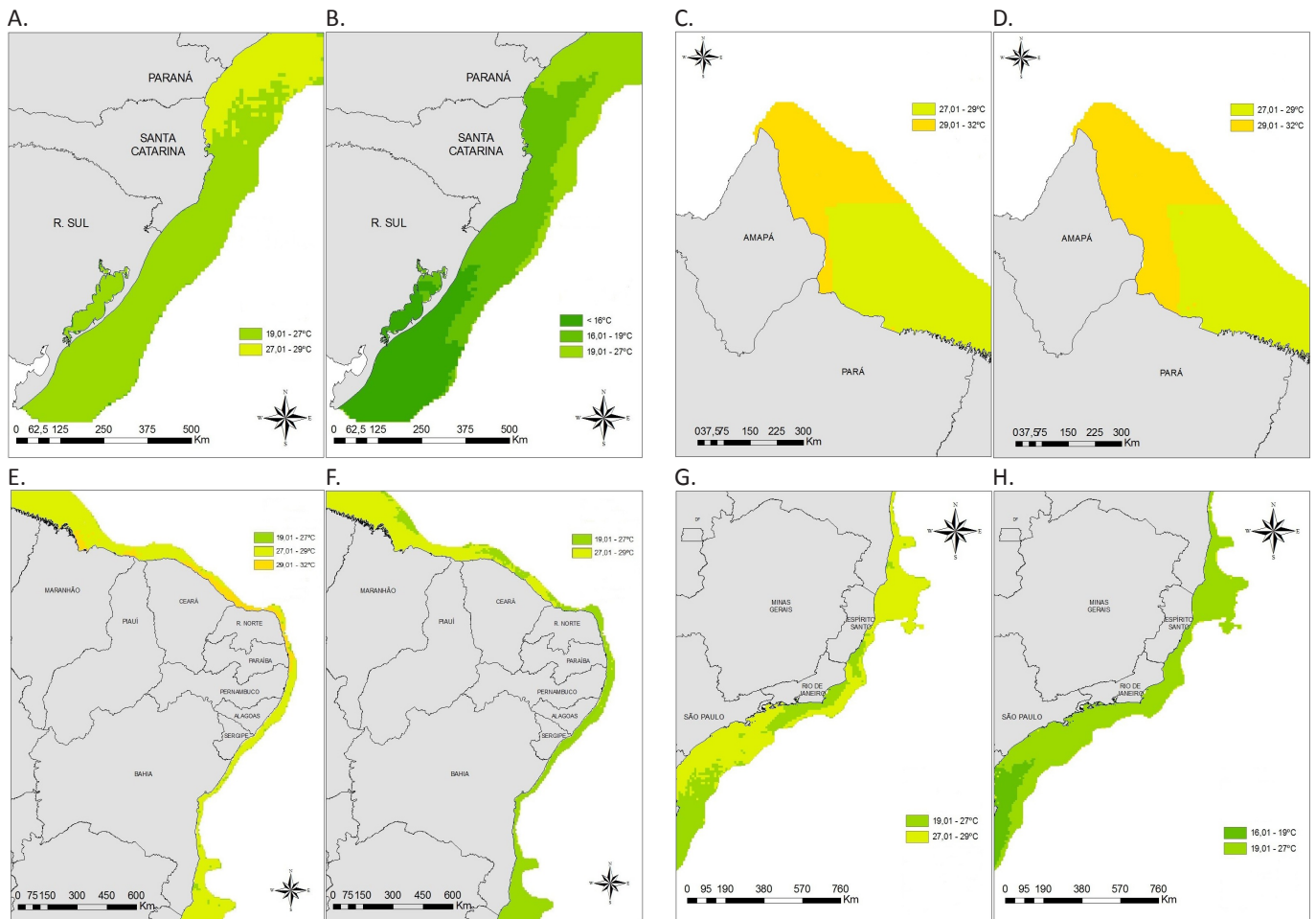
In northern Brazil, the mean SST in the largest portion of the coast of the state of Pará remained within the temperature range considered optimal for cobia growth (between 27–29 °C) in summer (Figure 1C) and winter (Figure 1D). On the coast of Amapá, however, mean SST ranged between 29–32 °C throughout the year, turning this into a region where cobia would probably show moderate growth (Class F; Table 1). Temperatures above the optimal range negatively affect fish growth (Baldisserotto, 2013), as they raise respiratory metabolism and increase maintenance demands and energy expenditure (Brett & Groves, 1979). In the specific case of cobia, Sun et al. (2006) demonstrated that high temperature levels accelerated metabolic activity, leading to higher food intake and digestion rate, which altered feed conversion efficiency. These authors also found a marked decline in specific growth rates and feed conversion

efficiency in cobia maintained at or above 31 °C. Therefore, the coastal area that encompasses Amapá and western Pará presents temperatures above the range considered optimal for the growth of this species.

The northeast region of Brazil also produced seasonal variations of SST. During summer, the SST remained between 27–29 °C in most of the region (Figure 1E), although some coastal portions of the states of Maranhão, Ceará, Rio Grande do Norte, and Paraíba had mean SST between 29–32 °C, i.e., within the range considered to lead to moderate growth of cobia. In winter, the SST remained at the optimum temperature range in the states of Maranhão, Piauí, and part of Ceará (Figure 1F). From Rio Grande do Norte to Bahia, the average SST in winter was 26.2 °C (Table 2). It is worth noting, however, that compared to the southeast region, where the minimum SST during winter was 17.2 °C (Table 2), in the northeastern region, the minimum SST in winter was much higher (23.8 °C). In Taiwan, Miao et al. (2009) have shown that water temperature directly affects the profitability of cobia culture operations. Farms located in the Penghu area, where the average water temperature in winter is about 18 °C, are less profitable than those in the Pindong region, which usually has relatively higher temperatures.

The coast of southeastern Brazil yields water temperatures below the estimated optimal range (27–29 °C) for the growth of cobia, for most of the year (Table 2). Although during summer, all of the coast of São Paulo, and some coastal areas of Rio de Janeiro and Espírito Santo have mean SSTs within the optimal temperature range (Figure 1G), in winter, the mean SST remains between 19–27 °C (Figure 1H). This means

19-27 °C  
27-29 °C



**Figure 1.** Mean sea surface temperature (°C) along the Brazilian coast: (A) summer in the southern region, (B) winter in the southern region, (C) summer in the northern region, (D) winter in the northern region, (E) summer in the northeastern region, (F) winter in the northeastern region, (G) summer in the southeastern region, and (H) winter in the southeastern region.

that part of the year-long production cycle of cobia would take place at water temperatures that only allow moderate growth. Sampaio et al. (2011) confirmed that cobia growth in Angra dos Reis, Rio de Janeiro, decreased significantly at lower temperatures. From March to June, when water temperature remained above 23 °C, mean daily growth rate was estimated at 2.29%, while from July to October, when temperatures were below 23 °C, daily growth rate decreased to 0.33%. Similar results were reported for cage-reared cobia in the USA (Weirich et al., 2004) and India (Loka et al., 2016).

Compensatory growth, a phase of accelerated growth when favorable conditions are restored after a period of growth depression, could offset the negative effects of suboptimal temperature on fish performance. Although compensatory growth has been reported for cobia (Schwarz et al., 2007), these authors found that juveniles reared for 70 days either at 18 or 23 °C exhibited a higher specific growth rate after transfer to 29 °C, in comparison with cobia juveniles that were kept constantly at 29 °C. Transferred fish, however, did not achieve size parity with those constantly maintained at 29 °C.

Despite the slower growth during winter, cage culture of cobia is a flourishing activity in southeastern Brazil (Rombenso et al., 2016). In this case, one has to consider that the proximity

to large consumer markets with great purchasing power, and the abundance of protected marine areas that allows the use of rearing structures with comparatively lower installation and operating costs than offshore farms (Bezerra et al., 2016), turns cobia culture into an attractive pursuit, even in areas with milder temperatures, where growth is not so fast. This highlights the need to consider factors, other than water temperature, when assessing the adequacy of a certain area for cage aquaculture. Among these, not only environmental issues should be considered, but also logistical, social, and economic aspects, as well as the legal framework (Benetti et al., 2010a; Kapetsky et al., 2013).

The assumption that a certain coastal area may not be suited for cage culture of cobia, because SST is out of the species optimal temperature range, may be misleading. On the other hand, if cage culture of cobia is to increase in Brazil in the medium/long term, there may be a tendency for commercial-scale aquaculture to be concentrated in the northern and northeastern regions, more specifically in the coastal strip extending from the east of the state of Pará to the north of Bahia. Based on the present results, this coastline presents the most adequate conditions of water temperature throughout the year for the commercial aquaculture of cobia.

## Acknowledgements

Thanks are due to the National Council for Scientific and Technological Development (CNPq) for the fellowship grants to L.N.S.S. Lima and R.O. Cavalli, and to the Coordination for the Improvement of Higher Education Personnel (CAPES) for the Ph.D. scholarship to T.R.Q. Bezerra.

## Literature Cited

- Atwood, H.L.; Young, S.P.; Tomasso, J.R.; Smith, T.I.J. Resistance of cobia, *Rachycentron canadum*, juveniles to low salinity, low temperature, and high environmental nitrite concentrations. *Journal of Applied Aquaculture*, v.15, n. 3-4, p.191-195, 2004. [https://doi.org/10.1300/J028v15n03\\_16](https://doi.org/10.1300/J028v15n03_16).
- Baldissierotto, B. Fisiologia de peixes aplicada à piscicultura. Santa Maria: Editora da UFSM, 2013. 349p.
- Benetti, D.D.; Benetti, G.I.; Rivera, J.A.; Sardenberg, B.; O'Hanlon, B. Site selection criteria for open ocean aquaculture. *Marine Technology Society Journal*, v.44, n.3, p.22-35, 2010a. <http://doi.org/10.4031/MTSJ.44.3.11>.
- Benetti, D.D.; O'Hanlon, B.; Rivera, J.A.; Welch, A.W.; Maxey, C.; Orhun, M.R. Growth rates of cobia (*Rachycentron canadum*) cultured in open ocean submerged cages in the Caribbean. *Aquaculture*, v.302, n.3-4, p.195-201, 2010b. <https://doi.org/10.1016/j.aquaculture.2010.02.021>.
- Bezerra, T.R.Q.; Domingues, E.C.; Maia Filho, L.F.A.; Rombenso, A.N.; Hamilton, S.; Cavalli, R.O. Economic analysis of cobia (*Rachycentron canadum*) cage culture in large- and small-scale production systems in Brazil. *Aquaculture International*, v.24, n. 2, p.609-622, 2016. <https://doi.org/10.1007/s10499-015-9951-2>.
- Bjornsson, B.; Steinarsson, A.; Oddgeirsson, M. Optimal temperature for growth and feed conversion of immature cod (*Gadus morhua* L.). *ICES Journal of Marine Sciences*, v.58, n. 1, p.29-38, 2001. <https://doi.org/10.1006/jmsc.2000.0986>.
- Brett, J.R.; Groves, T.D.D. Physiological energetics. In: Hoar, W.S.; Randall, D.J.; Brett, J. R. (Eds.). *Fish physiology*. New York: Academic Press, 1979. p.280-352.
- Food and Agriculture Organization of the United Nations – FAO. Fisheries and Aquaculture Department. FishStatJ. software for fishery statistical time series. Version 3.04.5. Rome: FAO; Fisheries and Aquaculture Department; Statistics and Information Service, 2018.
- Hamilton, S.; Severi, W.; Cavalli, R.O. Biologia e aquicultura do beijupirá: uma revisão. *Boletim do Instituto de Pesca*, v.39, n. 4, p.461-477, 2013. [https://www.pesca.sp.gov.br/39\\_4\\_461-477.pdf](https://www.pesca.sp.gov.br/39_4_461-477.pdf). 22 Feb. 2018.
- Hassler, W.W.; Rainville, R.P. Techniques for hatching and rearing cobia, *Rachycentron canadum*, through larval and juvenile stages. Raleigh: University of North Carolina, 1975. 26p. (Sea Grant Publication UNC-SG-75-30).
- Kapetsky, J.M.; Aguilar-Manjarrez, J.; Jenness, J. A global assessment of offshore mariculture potential from a spatial perspective. Rome: FAO, 2013. 181p. (FAO. Fisheries and Aquaculture Technical Paper, 549).
- Liao, I.C.; Huang, T.S.; Tsai, W.S.; Hsueh, C.M.; Chang, S.L.; Leaño, E.M. Cobia culture in Taiwan: current status and problems. *Aquaculture*, v.237, n. 1-4, p.155-165, 2004. <https://doi.org/10.1016/j.aquaculture.2004.03.007>.
- Liao, I.C.; Leaño, E.M. Cobia aquaculture: research, development and commercial production. 1.ed. Taiwan: Asian Fisheries Society, 2007. 178p.
- Loka, J.; Philipose, K.K.; Vaidya, N.G.; Sonali, S.M.; Dube, P. Variations in growth rates of cage cultured Asian seabass *Lates calcarifer* (Bloch, 1790) and cobia *Rachycentron canadum* (Linnaeus, 1766) in relation to environmental quality of marine farm at Karwar, India. *Indian Journal of Fisheries*, v.61, n. 3, p.140-145, 2016. <https://doi.org/10.21077/ijf.2016.63.3.57352-21>.
- McDonald, D.L.; Bumguardner, B.W. Lower lethal temperature for juvenile cobia *Rachycentron canadum*. *Journal of Applied Aquaculture*, v.22, n. 1, p.25-29, 2010. <https://doi.org/10.1080/10454430903539111>.
- Miao, S.; Jen, C.C.; Huang, C.T.; Hu, S.H. Ecological and economic analysis for cobia *Rachycentron canadum* commercial cage culture in Taiwan. *Aquaculture International*, v.17, n. 2, p.125-141, 2009. <https://doi.org/10.1007/s10499-008-9185-7>.
- Nhu, V.C.; Nguyen, H.Q.; Le, T.L.; Tran, M.T.; Sorgeloos, P.; Dierckens, K.; Reinertsen, H.; Kjørsvik, E.; Svennevig, N. Cobia *Rachycentron canadum* aquaculture in Vietnam: recent developments and prospects. *Aquaculture*, v.315, n. 1-2, p.20-25, 2011. <https://doi.org/10.1016/j.aquaculture.2010.07.024>.
- Rombenso, A.N.; Araujo, A.; Rodrigues, R.V. A promissora maricultura da Baía da Ilha Grande. *Panorama da Aquicultura*, v.25, p.34-41, 2016.
- Sampaio, L.A.; Moreira, C.B.; Miranda Filho, K.C.; Rombenso, A.N. Culture of cobia *Rachycentron canadum* (L) in near-shore cages off the Brazilian coast. *Aquaculture Research*, v.42, n. 6, p.832-834, 2011. <https://doi.org/10.1111/j.1365-2109.2010.02770.x>.
- Schwarz, M.H., Mowry, D., McLean, E.; Craig, S.R. Performance of advanced juvenile cobia, *Rachycentron canadum*, reared under different thermal regimes: evidence for compensatory growth and a method for cold banking. *Journal of Applied Aquaculture*, v.19, n. 4, p.71-84, 2007. [https://doi.org/10.1300/J028v19n04\\_04](https://doi.org/10.1300/J028v19n04_04).
- Shaffer, R.V.; Nakamura, E.L. Synopsis of biological data on the cobia *Rachycentron canadum* (Pisces: Rachycentridae). Washington: Department of Commerce; NOAA, 1989. 21p. (NOAA Technical Report NMFS 82).
- Sun, L.; Chen, H. Effects of ration and temperature on growth, fecal production, nitrogenous excretion and energy budget of juvenile cobia (*Rachycentron canadum*). *Aquaculture*, v.292, n. 3-4, p.197-206, 2009. <https://doi.org/10.1016/j.aquaculture.2009.04.041>.
- Sun, L.; Chen, H. Effects of water temperature and fish size on growth and bioenergetics of cobia (*Rachycentron canadum*). *Aquaculture*, v.426-427, p.172-180, 2014. <https://doi.org/10.1016/j.aquaculture.2014.02.001>.
- Sun, L.; Chen, H.; Huang, L. Effect of temperature on growth and energy budget of juvenile cobia (*Rachycentron canadum*). *Aquaculture*, v.261, n. 3, p.872-878, 2006. <https://doi.org/10.1016/j.aquaculture.2006.07.028>.

- Weirich, C.R.; Smith, T.I.J.; Denson, C.R.; Stokes, A. D.; Jenkins, W.E. Pond culture of larval and juvenile coxia, *Rachycentron canadum*, in the Southeastern United States: initial observations. *Journal of Applied Aquaculture*, v.16, n. 1, p.27-44, 2004. [https://doi.org/10.1300/J028v16n01\\_02](https://doi.org/10.1300/J028v16n01_02).
- Yu, S.L.; Ueng, P.S. Impact of water temperature on growth in coxia, *Rachycentron canadum*, cultured in cages. *Israel Journal of Aquaculture – Bamidgeh*, v.59, n. 1, p.47-51, 2007. <http://hdl.handle.net/10524/19209>. 22 Feb. 2018.