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Risk Assessment

Risks to eastern Pacific marine ecosystems from sea-cage mariculture of alien Cobia

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Abstract

Mariculture of Cobia (*Rachycentron canadum*) has become popular in various regions of the world due to the species' hardiness, fast growth and high market value. Despite not being native to the Eastern Pacific, Cobia was introduced for offshore sea-cage aquaculture in Ecuador in 2015, with the first Cobia escape occurring there several months after that culture effort began. Here, we report on new sightings of mature Cobia in the Colombian Pacific coast in 2017 with evidence that this alien fish is able to integrate into food webs and reproduce in the region. Using a decision-support tool developed for aquatic species (Aquatic Species Invasiveness Screening Kit, AS-ISK), we screened Cobia to identify its potential of becoming invasive in the tropical eastern Pacific (TEP). Based on the present state of knowledge, AS-ISK results indicated that Cobia has a medium to high risk of becoming invasive in this region. These results indicate that Cobia sea-cage mariculture in the TEP is not advisable. Carangid fishes native to the TEP that are already used in sea-cage aquaculture elsewhere provide an alternative to Cobia mariculture.

Key words: *Rachycentron canadum*, sea cage mariculture, risk assessment, AS-ISK, tropical eastern Pacific

Introduction

The Cobia (*Rachycentron canadum*), a hardy, fast growing, predatory pelagic fish, has become a poster child for international mariculture. Until recently, it was cultured only in its natural geographic range: the tropical and subtropical Atlantic and Indo-west Pacific (Benetti et al. 2008). The risk of introducing a large (up to 2 m and 68 kg; Collette et al. 2015), opportunistic, alien predator of crustaceans and fishes to the Eastern Pacific, where it does not naturally occur (Shaffer and Nakamura 1989; Collette et al. 2015), was ignored when Cobia mariculture was approved in 2013 by Ecuadorian authorities. Mariculture sea-cages invariably leak fish, sometimes en masse (Jensen et al. 2010), and, in August 2015, four months after mariculture began in Ecuador, thousands of juvenile Cobia escaped from a sea-cage near Manta in the Manabí province (Castellanos-Galindo et al. 2016). Juvenile escapees were caught 600 km away in October in Colombia, and 1000 km away in November in Panama (Vega et al. 2016). Given the number released, Cobia could become established in the Eastern Pacific if most escapees do not die before they mature (at ~ 2y and ~ 75cm total length; Shaffer and Nakamura 1989; Collette et al. 2015).

In the present study, new sightings of larger cobia in the tropical eastern Pacific (TEP) are reported and an initial screening of the potential for cobia to become invasive in the region is presented. A decision-support risk-screening tool widely used for aquatic organisms is applied to current information that bears on the Cobia case as a first step towards assessing the potential effects of Cobia's presence in the TEP.

Methods

Following the release of young Cobia from sea-cages in Ecuador and their capture in different coastal areas of the TEP, a call to report new sightings of this

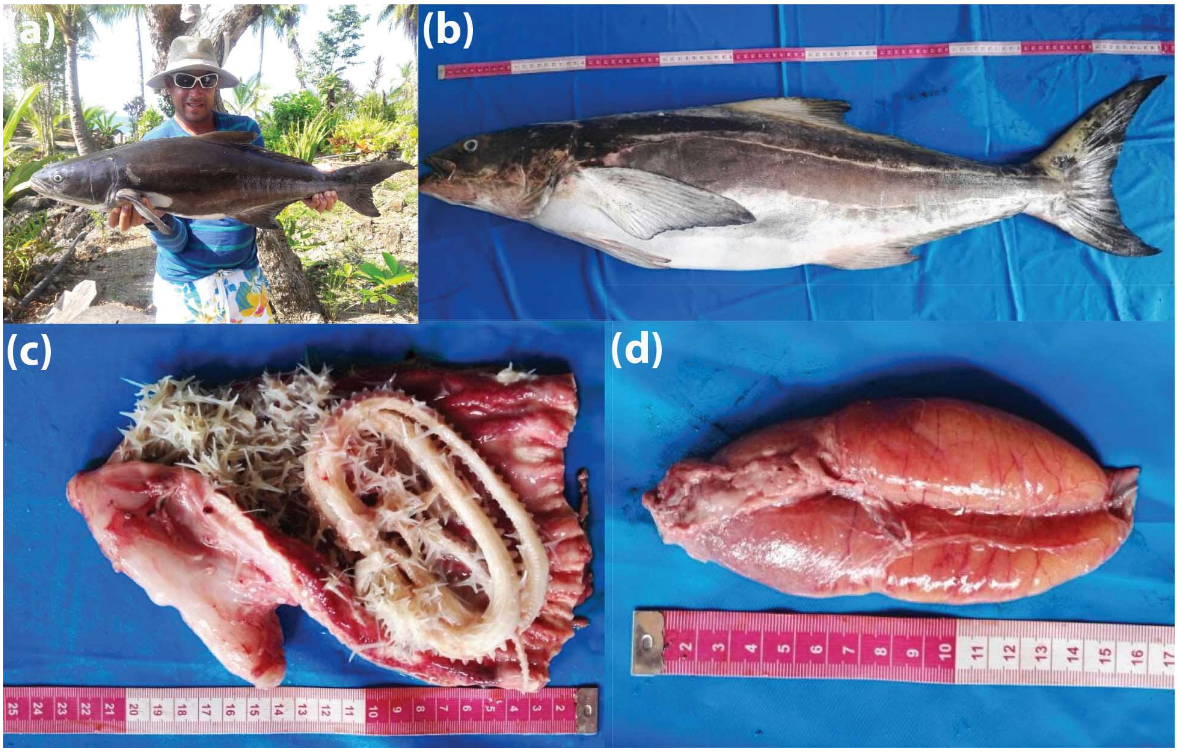

Figure 1. Cobia specimens found in March and April 2017 at (a) Cabo Corrientes and (b) Bahía Málaga in the northern and central Colombian Pacific coast, Tropical Eastern Pacific. (c) Stomach contents (skeleton of an eel and spines and tooth plates of a *Diodon* sp. fish) and (d) eggs from a ripe cobia found in Bahía Málaga. Photographs by Victor Quintero (a) and Cristina Pretel Vásquez (b,c and d).

fish was made by different agencies in the region. Regular monitoring at fish-landing sites in Colombia has been carried out by government agencies and NGOs. Additionally, a decision-support tool: the Aquatic Species Invasiveness Screening Kit (AS-ISK); was used to assess the risk of Cobia becoming invasive in the TEP. AS-ISK (Copp et al. 2016) is a tool designed to screen non-native species and identify which ones are likely to be invasive. This tool was adapted from the Weed Risk Assessment proposed by Pheloung et al. (1999), with versions used to screen freshwater fishes (FISK v1 and v2) and other aquatic biota (Copp 2013). The most recent version, AS-ISK, can be used to identify potentially invasive organisms in any aquatic environment (i.e. marine, brackish and freshwater: Copp et al. 2016). This version has been reported to be consistent with the minimum standards for invasive-species risk-assessment protocols (Roy et al. 2018). AS-ISK contains a list of 55 questions that are answered to complete the assessment. The first 49 questions (Basic Risk Assessment – BRA) are divided in two sections: (1) biogeographical and historical traits of the evaluated taxon – 13 questions, and (2) biological and ecological interactions – 36 questions. The remaining six questions comprise the Climate Change Assessment (CCA) module and are intended to evaluate risks associated to predicted changes in climate (see Table S1 in Copp et al. 2016). For each question, the assessor provides a level of confidence (1 = low; 2 = medium; 3 = high; 4 = very high) and information used to achieve that level, with those confidence rankings mirroring rankings recommended by the International Program on Climate Change (IPCC 2005; Copp et al. 2016). A confidence factor (CF) is then computed according to:

$$\sum (CQ_i)/(4 \times 55)$$

where i are the questions 1 to 55 and CQ_i is the level of confidence for question i. CF ranges from 0.25 when all questions are answered with a low level of confidence (i.e. 1) to 1.0 when all questions are answered with a very high level of confidence (i.e. 4).

Results and discussion

On March and April 2017, less than two years after the first escape, two new and much larger Cobia (~ 9–11 kg, 101–120 cm total length) were caught by artisanal and recreational fishers in the central and northern part of the Pacific coast of Colombia (Figure 1). These two Cobias were females with large, active ovaries and their stomach contents included skeletal remains of porcupinefishes (Diodontidae) and eels (Anguilliformes). These observations demonstrate that Cobia has been able to integrate successfully with the regional food-web, and to mature in the TEP.

The risk assessment (see Table 1 and Supplementary material Table S1) produced a BRA score of 20, which places Cobia at the lower end of the High Risk category (Gordon H. Copp, personal communication, April 2018). For comparison, the maximum possible BRA score is 68, and a screening of Lionfish (*Pterois miles*), which is well known to be invasive in the Caribbean Sea, produced BRA scores of 36 (G.H. Copp, personal communication, April 2018; Copp et al. 2016). The result of this Cobia screening, with a relatively high level of confidence (Table 1, Table S1), supports the assertion that there are distinct risks involved in allowing Cobia to establish a population in the TEP. The score our assessment produced was based on current information; confirmed establishment of a population would have produced a higher score. Below we describe the scoring for this species.

Biogeography/Historical. A low score in this section (1) is mostly attributable to the fact that due to the very recent introduction of the species in the TEP, nothing is known about any adverse impacts of this species in the introduced range. Moreover, since Cobia is distributed in the Atlantic and the Western Pacific oceans, the only major ocean region where it could be introduced is the TEP. Consequently questions in this section relating to whether Cobia is invasive elsewhere were answered with “No”. However, the fact Cobia lives in areas with widely varying salinity and temperature regimes indicates that the species likely can adapt to environmental conditions in the TEP.

Biology/Ecology. Five out of 12 undesirable trait questions were positively answered for Cobia, indicating that this species has some characteristics that could potentially make it invasive in the TEP: (1) Cobia is found in a variety of coastal habitats; (2) it is a predator; (3) it is able to reach maturity at relatively young age (1–2 years); (4) it is highly fecund; and (5) it produces planktonic eggs and larvae that could be easily dispersed by currents (Shaffer and Nakamura 1989).

Climate change. Three out of six questions in the Climate Change Module of AS-ISK were answered positively, while two scored negatively due to the uncertainty of the effects climate change has on potential impacts of Cobia introduction in this region. Under the predicted climate change scenarios, Cobia establishment risk, dispersal, and magnitude of its impacts in the TEP, were all expected to increase (Table S1). El Niño events are associated with extensions in the latitudinal ranges of shore-fishes in the TEP (Mora and Robertson 2005). El Niño sea surface temperature amplitude is expected to increase in the coming decades in the Eastern Pacific (Kim et al. 2014), indicating the potential for range increases in coastal pelagic fishes like Cobia. Therefore, given the wide temperature ranges (16° to 32 °C) in Cobia’s native range (Kaiser and Holt 2005), we expect that it could expand poleward north and south of the TEP during El Niño events and with global warming.

Table 1. Summary of AS-ISK scores for Cobia in the Eastern Pacific (see Table S1 for details). Details on the scoring system can be found in Table S1 of Copp et al. (2016). Confidence values ranged from a minimum of 0.25 (low confidence) to a maximum of 1.0 (high confidence)

Statistics	Score
Basic Risk Assessment (BRA)	20.0
BRA + Climate Change Assessment (CCA)	26.0
Confidence	0.70
A. Biogeography/Historical	1.0
1. Domestication/Cultivation	2.0
2. Climate, distribution and introduction risk	1.0
3. Invasive elsewhere	−2.0
B. Biology/Ecology	19.0
4. Undesirable (or persistence) traits	6.0
5. Resource exploitation	7.0
6. Reproduction	1.0
7. Dispersal mechanisms	4.0
8. Tolerance attributes	1.0
C. Climate change	6.0
9. Climate change	6.0

Sea-cages invariably leak fish and continuation of sea-cage Cobia mariculture in Ecuador will inevitably lead to more escapes (see http://www.expreso.ec/economia/los-pescadores-alertan-de-un-nuevo-escape-de-cobias-NE95194), which could prove critical for the establishment of a self-sustaining population in the wild in that region. A spreading population of Cobia would have unpredictable effects on the biodiversity and fisheries of the ten countries that border the TEP, as well as the Cobia-free central Pacific (see Figure S1 for Cobia’s suitable habitat map). The havoc caused by invasive Indo-Pacific Lionfish throughout the Caribbean (Morris 2012) provides a compelling lesson about the strong adverse effects that alien predatory fish can have on naïve marine ecosystems. The extraordinary success of the

Lionfish in the Caribbean is due in large part to both its prey and its potential predators having no prior experience with a type of fish that has no near relatives or ecological analogs amongst the Caribbean (or Atlantic) fish fauna (Côté and Smith 2018). Cobia is a hardy species, able to cope with environments between 0–80 m depth in both coastal and open ocean waters, temperatures between 17–32 °C, and salinities from 5–44.5 psu. Further, the species is long-lived (to 15 y), reaches a large size and has a wide diet breath (Shaffer and Nakamura 1989). As Cobia is the only species in its family (Rachycentridae), and is most closely related to remoras or shark-suckers (Nelson et al. 2016), it too represents an unusual type of predator in its introduced region. This increases both the degree of uncertainty about its effects and the potential for major disruption of the area's marine ecosystems. The shore-fish fauna of the TEP is relatively depauperate in terms of species richness (Robertson and Cramer 2009), which may facilitate the establishment of a species like Cobia, which is native to a higher-diversity region (cf. Kimbro et al. 2013). The TEP also has a very high level of regional endemism among its shore-fishes (~ 80%, Robertson and Cramer 2009), which increases the potential for adverse effects of an alien predator on regional biodiversity.

Open-ocean aquaculture is often pictured as a beneficial and promising alternative to meet growing protein-demands of expanding human populations (Gentry et al. 2017). The Government of Ecuador has, since the 1960s, been actively interested in expanding its aquaculture sector (Alvarado et al. 2016). This expansion has sometimes produced catastrophic environmental damage in coastal areas, such as loss of large areas of mangroves (Hamilton 2013). Expansion of the (offshore) aquaculture sector anywhere in the TEP needs to be weighed against the unpredictable risks associated with the introduction of alien species (Rejmánek and Simberloff 2017), which includes Cobia. A focus on the use of native species would avoid such problems entirely. For example, species of Amberjacks (*Seriola* spp.*)* are pelagic predators like Cobia, but are also part of the native Eastern Pacific fish fauna (www.stri.org/sftep). Amberjacks are regularly used elsewhere for sea-cage aquaculture, and have similar food conversion ratios as Cobia (Abbink et al. 2012; Benetti et al. 2007). Froehlich et al. (2017) acknowledged that aquaculture is often viewed as a foe to conservation efforts. Aquaculture that involves the deliberate introduction of new alien predators to large ecosystems where they previously were absent does not contribute to "shifting the narrative" about this activity's role in resource management and conservation.

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Supplementary material

The following supplementary material is available for this article:

Table S1. AS-ISK v1 input and output for Cobia *Rachycentron canadum* in the tropical Eastern Pacific.

Figure S1. Suitable habitat map for Cobia *Rachycentron canadum* generated with Aquamaps.

This material is available as part of online article from:

http://www.reabic.net/journals/mbi/2018/Supplements/MBI_2018_Castellanos-Galindo_etal_Table_S1.xlsx

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