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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

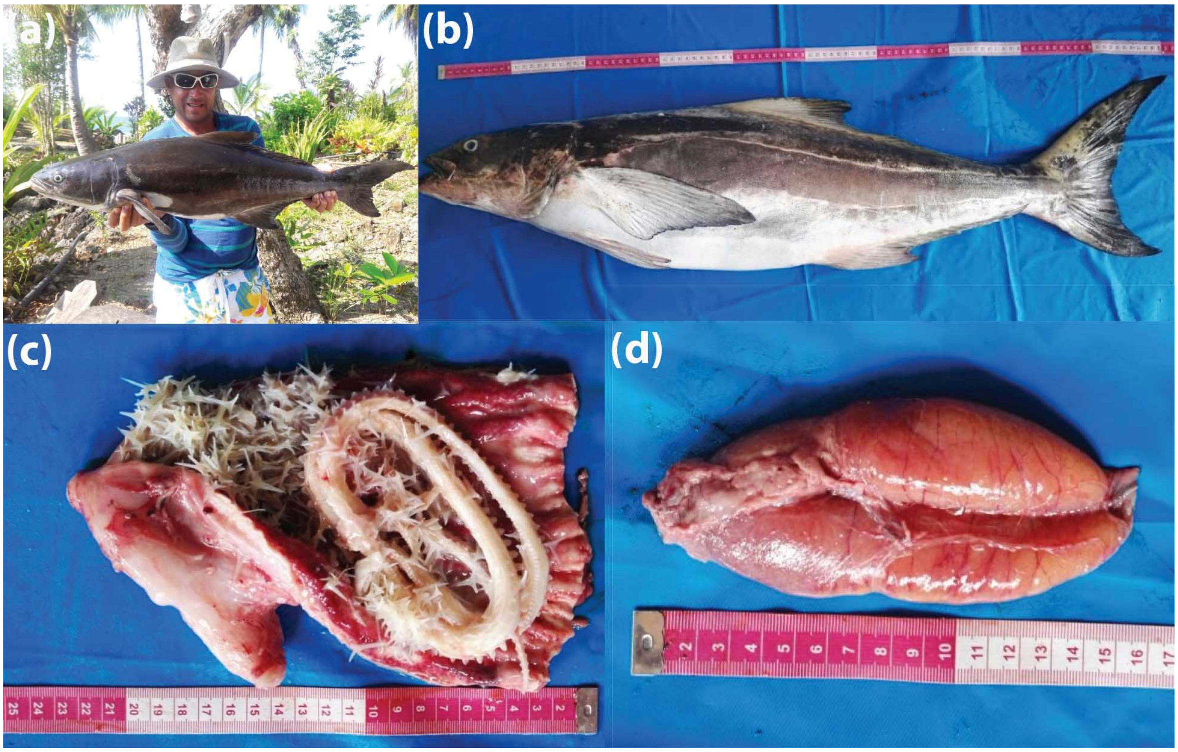

Figure 1. Cobia specimens found in March and April 2017 at (a) Cabo Corrientes and (b) Bahía Málaga in the northern and central Colombian Pacific coast, Tropical Eastern Pacific. (c) Stomach contents (skeleton of an eel and spines and tooth plates of a *Diodon* sp. fish) and (d) eggs from a ripe cobia 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
http://www.reabic.net/journals/mbi/2018/Supplements/MBI_2018_Castellanos-Galindo_etal_Figure_S1.pdf

Supplementary material

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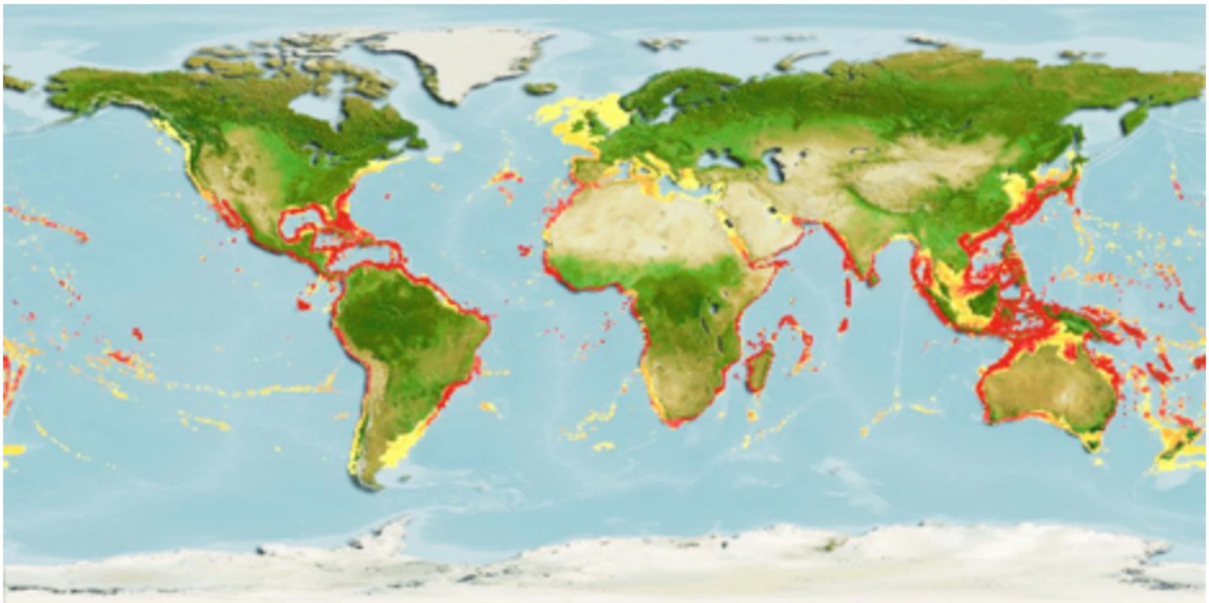

Supplementary material

Table number	Table abbreviation	Table title
Table S1	Table S1	AS-ISK v1 input and output for Cobia Rachycentron canadum in the tropical Eastern Pacific

Recommended Citation of this material

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

AS-ISK v1

Taxon and Assessor details	
Category	Fish (marine)
Taxon name	*Rachycentron canadum*
Common name	Cobia
Assessor	GA Castellanos-Galindo & DR Robertson
Risk screening context	
Reason	The scpecies was first introduced to Ecuador in the Eastern Pacific, in 2015, by an aquaculture company
Risk Assessment Area	tropical eastern Pacific
Taxonomy	Rachycentron canadum (Linnaeus, 1766)
Native range	Subtropical and tropical waters of the Atlantic and Indo-Pacific Oceans (not in the Eastern Pacific, or the eastern 2/3 of the Pacific ocean)
Introduced range	Eastern Pacific
URL	http://www.iucnredlist.org/details/190190/0

			Response	Justification	Confidence	References
A. Biogeography/Historical						
1. Domestication/Cultivation						
1	1.01	Has the taxon been the subject of domestication (or cultivation) for at least 20 generations?	Yes	Cobia aquaculture started in the 1990's in Taiwan. Since then cobia aquaculture has expanded in South East Asia and the Caribbean	Very high	Bennetti et al. 2008; Chang et al. 1999; Liao et al. 2004
2	1.02	Is the taxon harvested in the wild and likely to be sold or used in its live form?	Yes	Cobia is considered an excellent target species in recreational fisheries, including the southern USA. Various countries in the Eastern Central Atlantic report catches of Cobia (Benin, Gambia and Senegal)	Very high	Collette et al. 2015
3	1.03	Does the taxon have invasive races, varieties, sub-taxa or congeners?	No	Cobia is a monotypic genus and family; no races or varieties are known. The introduction to the east Pacific in 2015 was the first outside its native range.	Very high	Shaffer & Nakamura 1989
2. Climate, distribution and introduction risk						
4	2.01	How similar are the climatic conditions of the RA area and the taxon's native range?	High	Cobia is reported in tropical and subtropical areas of the Western Pacific and Atlantic Oceans. It has been recorded from areas with water temperatures ranging from 16° to 32°C and salinities from 22.5 to 44.5 psu. Trials have been made to culture cobias at low salinities (5psu) indicating optimal growth. The tropical eastern Pacific temperatures and salinities match well with the climatic conditions of cobia in its native range. The relative probability of cobia occurrence in the tropical eastern Pacific is high according to Aquamaps	High	Shaffer & Nakamura 1989; Resley et al. 2006
5	2.02	What is the quality of the climate matching data?	High	Derived from an Aquamap of the global distribution of suitable habitat…see Figure S1	High	Computer generated distribution maps for Rachycentron canadum (Cobia), with modelled year 2100 native range map based on IPCC A2 emissions scenario. www.aquamaps.org, version of Aug. 2016. Web. Accessed 3 Apr. 2018.
6	2.03	Is the taxon already present outside of captivity in the RA area?	Yes	Following a mass escape from a seacage in Ecuador in late 2015, Cobia were captured in Pacific coastal waters of Panama, Colombia, Ecuador and Peru	Very high	Castellanos-Galindo et al. 2016
7	2.04	How many potential vectors could the taxon use to enter in the RA area?	One	The only known pathway is seacage aquaculture, which is occurring in Ecuador. Cobia has never been recorded east of the Solomon Islands, 10,000-13,000 km from the East Pacific.	Very high	Castellanos-Galindo et al. 2016
8	2.05	Is the taxon currently found in close proximity to, and likely to enter into, the RA area in the near future (e.g. unintentional and intentional introductions)?	Yes	As long as the sea-cage aquaculture continues in Ecuador, it will be found in close proximity	Very high	Castellanos-Galindo et al. 2016
3. Invasive elsewhere						
9	3.01	Has the taxon become naturalised (established viable populations) outside its native range?	No	Cobia has been introduced as an alien only to the Eastern Pacific, and only since 2015. No records of successful reproduction in this area exist, although gravid females were caught in Pacific Colombia in 2017	Very high	
10	3.02	In the taxon's introduced range, are there known adverse impacts to wild stocks or commercial taxa?	No	This is not known yet	Medium	
11	3.03	In the taxon's introduced range, are there known adverse impacts to aquaculture?	No	None known	High	
12	3.04	In the taxon's introduced range, are there known adverse impacts to ecosystem services?	No	This is not known yet	Medium	
13	3.05	In the taxon's introduced range, are there known adverse socio-economic impacts?	No	Aquaculture in Ecuador is advertised as being benefitial for the countries economy.	Medium	
B. Biology/Ecology						
4. Undesirable (or persistence) traits						
14	4.01	Is it likely that the taxon will be poisonous or pose other risks to human health?	No	No, cobia can by ciguatoxic but there is no Ciguatera in the tropical eastern Pacific	High	Matei et al. 2014
15	4.02	Is it likely that the taxon will smother one or more native taxa (that are not threatened or protected)?	No	No	Medium	
16	4.03	Are there threatened or protected taxa that the non-native taxon would parasitise in the RA area?	No	No, Cobia is a predator, not a parasite	High	
17	4.04	Is the taxon adaptable in terms of climatic and other environmental conditions, thus enhancing its potential persistence if it has invaded or could invade the RA area?	Yes	Cobia can live in a wide variety of environments	Very high	Collette et al. 2015
18	4.05	Is the taxon likely to disrupt food-web structure/function in aquatic ecosystems it has or is likely to invade in the RA area?	Yes	Cobia collected in the Eastern Pacific in 2017 have been shown to integrate into local food webs, as the present paper shows	Medium	This study
19	4.06	Is the taxon likely to exert adverse impacts on ecosystem services in the RA area?	No	Not known	Low	http://www.elcomercio.com/actualidad/intranquilidad-pez-depredador-cobia-costa.html
20	4.07	Is it likely that the taxon will host, and/or act as a vector for, recognised pests and infectious agents that are endemic in the RA area?	Yes	It is possible because Cobia are raised in sea-cages in Ecuador	Medium	
21	4.08	Is it likely that the taxon will host, and/or act as a vector for, recognised pests and infectious agents that are absent from (novel to) the RA area?	Yes	It is possible if fry used in aquaculture in Ecuador are introduced from sites outside the eastern Pacific rather than being produced locally.	Medium	
22	4.09	Is it likely that the taxon will achieve a body size that will make it more likely to be released from captivity?	No	Cobia can grow up to 2 m, but any accidental releases are unlikely to be related to body size, except that harvesting likely will be done at a much smaller size than the maximum, so the biggest fish will not be available for release in the E Pacific	High	
23	4.10	Is the taxon capable of sustaining itself in a range of water velocity conditions (e.g. versatile in habitat use)?	Yes	Cobia is a pelagic species with very good swimming abilities	Very high	Collette et al. 2015

24	4.11	Is it likely that the taxon's mode of existence (e.g. excretion of by-products) or behaviours (e.g. feeding) will reduce habitat quality for native taxa?	No	Not known	Medium	
25	4.12	Is the taxon likely to maintain a viable population even when present in low densities (or persisting in adverse conditions by way of a dormant form)?	Yes	Cobia is a solitary species and is mostly found in low densities in its native range	Medium	Shaffer & Nakamura 1989
5. Resource exploitation						
26	5.01	Is the taxon likely to consume threatened or protected native taxa in RA area?	Yes	Cobia is a predator, with a generalized diet, and potentially could prey on threatened invertebrates and fish in the tropical eastern Pacific	Medium	This study
27	5.02	Is the taxon likely to sequester food resources (including nutrients) to the detriment of native taxa in the RA area?	Yes	Cobia could compete with native fishes in the tropical eastern Pacific	Medium	This study
6. Reproduction						
28	6.01	Is the taxon likely to exhibit parental care and/or to reduce age-at-maturity in response to environmental conditions?	No	Cobia has planktonic eggs and does not have parental care	High	Collette et al. 2015
29	6.02	Is the taxon likely to produce viable gametes or propagules (in the RA area)?	Yes	This is likely as environmental conditions in the tropical eastern Pacific are similar to those in cobia's native range, and gravid female Cobia were caught in Pacific waters of Colombia in 2017	Low	Collette et al. 2015
30	6.03	Is the taxon likely to hybridize naturally with native taxa?	No	No, Cobia is the only species in the genus and the family	High	Shaffer & Nakamura 1989
31	6.04	Is the taxon likely to be hermaphroditic or to display asexual reproduction?	No	No. Cobia is gonochoristic and asexual reproduction has not been reported in such fish	High	Shaffer & Nakamura 1989
32	6.05	Is the taxon dependent on the presence of another taxon (or specific habitat features) to complete its life cycle?	No	No. Cobia is a pelagic species that spawns in open water in coastal areas of its native range	High	Shaffer & Nakamura 1989
33	6.06	Is the taxon known (or likely) to produce a large number of propagules or offspring within a short time span (e.g. <1 year)?	Yes	Total fecundity for cobia has been estimated in 1.9 to 5.4 million eggs	High	Shaffer & Nakamura 1989
34	6.07	How many time units (days, months, years) does the taxon require to reach the age-at-first-reproduction? [In the Justification field, indicate the relevant time unit being used.]	2	Average: two years, range is 1-2 years	High	Collette et al. 2015; Shaffer & Nakamura 1989
7. Dispersal mechanisms						
35	7.01	How many potential internal pathways could the taxon use to disperse within the RA area (with suitable habitats nearby)?	>1	Cobia could disperse north and south from the sea-cage aquaculture location in in Ecuador	Very high	
36	7.02	Will any of these pathways bring the taxon in close proximity to one or more protected areas (e.g. MCZ, MPA, SSSI)?	Yes	There are several MPAs in the tropical eastern Pacific, including the Galapagos Islands	Very high	
37	7.03	Does the taxon have a means of actively attaching itself to hard substrata (e.g. ship hulls, pilings, buoys) such that it enhances the likelihood of dispersal?	No	Cobia is a pelagic species and do not need to attach to any substrate to disperse	High	
38	7.04	Is natural dispersal of the taxon likely to occur as eggs (for animals) or as propagules (for plants: seeds, spores) in the RA area?	Yes	Cobia produces planktonic eggs	Very high	Shaffer & Nakamura 1989
39	7.05	Is natural dispersal of the taxon likely to occur as larvae/juveniles (for animals) or as fragments/seedlings (for plants) in the RA area?	Yes	larval, juvenile and pelagic-adult dispersal is likely for cobia in the tropical eastern Pacific	Very high	
40	7.06	Are older life stages of the taxon likely to migrate in the RA area for reproduction?	Yes	Cobia might migrate to reproduce as it does in its native range	Very high	Shaffer & Nakamura 1989
41	7.07	Are propagules or eggs of the taxon likely to be dispersed in the RA area by other animals?	No	No	High	
42	7.08	Is dispersal of the taxon along any of the pathways mentioned in the previous seven questions (7.01–7.07; i.e. both unintentional or intentional) likely to be rapid?	Yes	Larval and juvenile-adult dispersal could be very rapid given the high swimming capacity of cobia and the water currents patterns in the tropical eastern Pacific. Juveniles were caught in Panama, 1000 km from the release point, three months after the 2015 escape from a seacage in Ecuador.	Very high	Castellanos-Galindo et al. 2016
43	7.09	Is dispersal of the taxon density dependent?	No	Not known	Medium	
8. Tolerance attributes						
44	8.01	Is the taxon able to withstand being out of water for extended periods (e.g. minimum of one or more hours) at some stage of its life cycle?	No	Not likely	Medium	
45	8.02	Is the taxon tolerant of a wide range of water quality conditions relevant to that taxon? [In the Justification field, indicate the relevant water quality variable(s) being considered.]	Yes	Cobia is considered a very hardy species tolerating wide salinity and temperture ranges	High	Shaffer & Nakamura 1989
46	8.03	Can the taxon be controlled or eradicated in the wild with chemical, biological, or other agents/means?	No	Not likely in the open ocean	High	
47	8.04	Is the taxon likely to tolerate or benefit from environmental/human disturbance?	No	Not known	Medium	
48	8.05	Is the taxon able to tolerate salinity levels that are higher or lower than those found in its usual environment?	Yes	Cobia's salinity range is 22-44psu, and has been aquacultured at 5 psu	High	Shaffer & Nakamura 1989; Resley et al. 2006
49	8.06	Are there effective natural enemies (predators) of the taxon present in the RA area?	Yes	There are other pelagic fishes and sharks in the East Pacific that likely will eat cobia, but most likely are heavily fished	High	Martinez-Ortiz et al. 2015
C. Climate change						
9. Climate change						
50	9.01	Under the predicted future climatic conditions, are the risks of entry into the RA area posed by the taxon likely to increase, decrease or not change?	No change	No change	Medium	
51	9.02	Under the predicted future climatic conditions, are the risks of establishment posed by the taxon likely to increase, decrease or not change?	Increase	More available habitat due to warmer waters extending further north and south of the tropical eastern Pacific might facilitate cobia establishment	Medium	
52	9.03	Under the predicted future climatic conditions, are the risks of dispersal within the RA area posed by the taxon likely to increase, decrease or not change?	Increase	Warmer temperatures in the tropical eastern Pacific might increase cobia's habitats to the south and north of the tropical eastern Pacific	High	Kaiser & Holt 2005
53	9.04	Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on biodiversity and/or ecological integrity/status?	Higher	Warmer temperatures may increase cobia's range and thus impacted areas	Low	
54	9.05	Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem structure and/or function?	No change	No change, not known	Medium	
55	9.06	Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem services/socio-economic factors?	No change	No change, not known	Low	

Statistics	
Scores	
BRA Score	**20.0**
BRA Outcome	**-**
BRA+CCA Score	**26.0**
BRA+CCA Outcome	**-**
Score partition	
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*
Answered	
Total	***55***
A. Biogeography/Historical	**13**
1. Domestication/Cultivation	*3*
2. Climate, distribution and introduction risk	*5*
3. Invasive elsewhere	*5*
B. Biology/Ecology	**36**
4. Undesirable (or persistence) traits	*12*
5. Resource exploitation	*2*
6. Reproduction	*7*
7. Dispersal mechanisms	*9*
8. Tolerance attributes	*6*
C. Climate change	**6**
9. Climate change	*6*
Sectors affected	
Commercial	**6**
Environmental	**9**
Species or population nuisance traits	**15**

Date and time	
Date and Time	**11/04/2018 09:40:52**
Thresholds	
Medium	**-**
High	**-**

Confidence	**0.70**

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