Revisions of the Fish Invasiveness Screening Kit (FISK) for its Application in Warmer Climatic Zones, with Particular Reference to Peninsular Florida

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[Correction added after online publication on October 4, 2012: In the title, "Scoring" was changed to "Screening".]

The initial version (v1) of the Fish Invasiveness Scoring Kit (FISK) was adapted from the Weed Risk Assessment of Pheloung, Williams, and Halloy to assess the potential invasiveness of nonnative freshwater fishes in the United Kingdom. Published applications of FISK v1 have been primarily in temperate-zone countries (Belgium, Belarus, and Japan), so the specificity of this screening tool to that climatic zone was not noted until attempts were made to apply it in peninsular Florida. To remedy this shortcoming, the questions and guidance notes of FISK v1 were reviewed and revised to improve clarity and extend its applicability to broader climatic regions, resulting in changes to 36 of the 49 questions. In addition, upgrades were made to the software architecture of FISK to improve overall computational speed as well as graphical user interface flexibility and friendliness. We demonstrate the process of screening a fish species using FISK v2 in a realistic management scenario by assessing the Barcoo grunter *Scortum barcoo* (Terapontidae), a species whose management concerns are related to its potential use for aquaponics in Florida. The FISK v2 screening of Barcoo grunter placed the species into the lower range of medium risk (score = 5), suggesting it is a permissible species for use in Florida under current nonnative species regulations. Screening of the Barcoo grunter illustrates the usefulness of FISK v2 as a proactive tool serving to inform risk management decisions, but the low level of confidence associated with the assessment highlighted a dearth of critical information on this species.

KEY WORDS: Alien species; nonnative fishes; risk assessment; risk screening

1. INTRODUCTION

Risk identification tools are the front line of the risk analysis process, assisting environmental managers in identifying which nonnative species are more likely to be invasive and are therefore amenable to detailed risk analysis. Building on the Weed Risk Assessment (WRA) of Pheloung *et al.*,(1) the Fish Invasiveness Scoring Kit (FISK) was adapted for use in the United Kingdom.(2,3) As with the WRA, FISK consists of 49 questions within two main sections (*Biogeography/History* and *Biology/Ecology*), and eight categories (*Domestication/Cultivation*; *Climate and Distribution*; *Invasive elsewhere*; *Undesirable traits*; *Feeding guild*; *Reproduction*; *Dispersal*

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mechanisms; *Persistence attributes*). The outcome scores range from −11 to 53, and these have been calibrated[3] into three levels of potential risk of a species being invasive: low (score <1), medium (1–19), high (≥19). FISK and its "sister" tools[4,5] were developed for the United Kingdom, a temperate-zone country, and subsequent applications have been in other temperate-zone countries including Belarus,[6] Belgium,[7,8] and Japan,[9] with additional applications completed or in progress for Australia,[10] Brazil,[11] Iberia (D. Almeida *et al.*, unpublished data), Finland (M. Lehtiniemi *et al.*, unpublished data), and the Balkan states of Serbia, Macedonia, Montenegro, and Bulgaria (P. Simonović *et al.*, unpublished data).

The specificity of FISK to the temperate zone was not appreciated until attempts were made to apply this screening tool in peninsular Florida (LLL, JEH, SH, and GHC, unpublished data) and Mexico (R. Mendoza, V.S. Aguirre, and L.G. Berúmen, unpublished data). To address this shortcoming, the aim of this study was to improve FISK in terms of its climatic applicability, in particular to regions with tropical/subtropical environments, and of its user interface. The specific objectives of this study were to: (1) complete a review and revision of FISK questions and related guidance; (2) undertake improvements to the FISK software graphical user interface (GUI) and therefore produce FISK v2; and (3) carry out a trial application of FISK v2 on a nonnative fish species of relevance to peninsular Florida. The resulting new version of FISK (v2) is applicable over a wider range of environmental conditions, is more user friendly and, ultimately, replaces its predecessor for use as an invasiveness screening tool.

2. METHODS

2.1. Question and Guidance Refinement

Questions and guidance in FISK v1 were critically reviewed with regard to peninsular Florida south of the Suwanee River, which has a subtropical climate. Particular attention was directed to characteristics that are considered to facilitate the invasions of tropical/subtropical environments by freshwater fishes, with the following criteria used in the revision process: (1) improved clarity, where changes reduced ambiguous terminology or uncertainty in interpretation of questions; (2) increased climatic suitability, where changes allowed for increased flexibility of climate-match source information or direct incorporation of physiological tolerances; and (3) enhanced ecological applicability, where modifications addressed a wider range of ecological characteristics.

FISK question amendments were discussed and executed during a two-week meeting in August 2011, with four of the co-authors at the University of Florida (LLL, JEH, SH, GHC) and one (LV) via electronic correspondence. During this review process, each of the four co-authors explained his interpretation of the questions, the guidance, and their likely response under different hypothetical scenarios, with insights from GHC into the intent of each question derived from the original adaption of FISK[2] from the WRA.[1] Once consensus was reached, the question and guidance were revised accordingly, and each of the previously listed criteria was discussed to determine whether or not additional changes were necessary. As a control measure, two project collaborators assessed the same two species, discussed the outcomes, and made final revisions to the questions and guidance.

2.2. Software Improvements

FISK consists of an electronic toolkit written in Excel® for VBA code.[12] The code was originally developed by Pheloung *et al.*[1] for their WRA toolkit and later adapted for use with FISK (including its Spanish version S-FISK) to accommodate all necessary changes for application to freshwater fish, and eventually to freshwater invertebrates (FI-ISK), marine invertebrates (MI-ISK), amphibians (AMPHISK), and marine fish (M-FISK).[2] The software architecture of the FISK family of programs is that of a "dictator application" (*sensu* Bovey *et al.*[13]). This represents an advanced level of Excel® application development in which virtually all features are controlled by the application itself. In the case of FISK, the user interface consists of tightly controlled data entry user forms that separate the user interface from the underlying data storage layer, resulting in a fully functional application that involves a high degree of control over user interaction.

Although FISK v1 already contained all essential features for species listing, questionnaire-based user input, and report generation, an upgrade to FISK v2 was deemed essential to improve overall computational speed as well as to provide for a higher level of flexibility and user friendliness, with special emphasis on the "interaction design"[14] of the two main user forms (or dialogs), namely: the *Species Assessment Menu* and the *Q&A* dialog. Programming was done in Microsoft Visual Basic for Applications 7.0 for Excel® 2010 for Windows® by LV under ongoing advice and feedback from the rest of the project team, who also participated in the beta testing phase along with an external expert (E. Tricarico, University of Florence, Italy).

2.3. Application

An example species was screened for peninsular Florida by SH using FISK v2. The Barcoo grunter *Scortum barcoo* (McCulloch & Waite, 1917), family Terapontidae, is a freshwater species endemic to the Lake Eyre basin in interior Australia and has been increasingly used in aquaculture as a food fish.[15] This species has been marketed as the jade perch for aquaponics (i.e., integrated fish and plant crop culture), and was chosen for assessment in this study because of the recent emergence of small-scale commercial and noncommercial aquaponics in Florida. Currently, there are no regulations governing the possession of Barcoo grunter in Florida, so FISK was used to determine whether a full risk assessment is warranted. The FISK assessment was reviewed by JEH to simulate a typical management agency scenario, where an assessment is produced and then reviewed by either an internal or external taxonomic expert. Thus, screening the Barcoo grunter serves to illustrate the process of assessing a fish species using FISK v2, provides real-world answers to FISK questions, and demonstrates its potential use as a practical tool for proactive management in warmer climate zones.

Relatively little is published on the Barcoo grunter in its native range; however, there is a growing body of literature on its husbandry. With a maximum size of about 35 cm standard length, the Barcoo grunter in its native range is found in low-gradient rivers subject to extreme flooding and drying,[16] extending over a temperature range of about 10–30 °C.[17] An omnivorous forager, the Barcoo grunter feeds on a wide variety of plant material, detritus, invertebrates, and, occasionally, small fish.[18,19] Spawning occurs during high-water periods.[20]

3. RESULTS

3.1. Question Refinement

Alterations were made to 36 of the 49 FISK questions and/or guidance notes in accordance with the revision criteria (Table I): 27 revisions to improve clarity, 3 to increase climatic suitability, and 14 to enhance ecological applicability. Some questions required multiple changes and were placed into more than one revision criterion.

3.1.1. Domestication/Cultivation (Table I, Section A1)

Domestication is considered to have the potential of enhancing the fitness of some freshwater fishes (i.e., increased growth rate, mating success, and/or fecundity) over wild strains,[21] and commercial production of ornamental species may also increase the intensity of introductions (i.e., propagule pressure).[22] However, commercially produced ornamental fish are often small-bodied (e.g., variable platyfish *Xiphophorus variatus* and swordtail *Xiphophorus hellerii*) and selected for bright coloration (e.g., transgenic zebra danio *Danio rerio*) or increased fin length (e.g., long-finned zebra danio varieties). This has been shown to increase their vulnerability to predation and decrease their likelihood of establishment in nonnative environments.[23,24] Therefore, guidance for question (henceforth "Q") 1.01 was modified to include an exception for ornamental and commercially produced species that have been selected for traits that are likely to reduce their fitness.

To reduce subjectivity, the term "naturalised" was replaced with "established self-sustaining populations" for Q 1.02 and throughout FISK v2. The term "naturalised" is a broad term that encompasses several phases of the invasion process, including establishment, colonization, and a measure of persistence through time,[25] and also implies some level of human acceptance of the nonnative fish into the native fish community. The term "established" reflects the definition from Shafland *et al.*,[26] i.e., nonnative fishes that have been consistently collected from public waterways, are unlikely to be eliminated, and that have persisted for an extended period of time relative to their life span.

3.1.2. Climate and Distribution (Table I, Section A2)

Climate matching models use computer analysis to match temperature and rainfall from a species' native range with conditions of the recipient environment. FISK v1 recommended the use of climate matching software to respond to the climate and distribution section with the highest level of certainty.[2] The certainty response modifies the score given for

Table I. List of the 49 Questions Making Up the Fish Invasiveness Scoring Kit (FISK) v2 with Highlighted (in Italics) Changes Relative to v1 (cf. Copp *et al.*[2])

Section/(Code)	#	Criteria	Query	Guidance
A. Biogeography/Historical				
1. Domestication/Cultivation				
1.01 (C)	1	CL, E	Is the species highly domesticated or *widely* cultivated for commercial, angling or ornamental purposes?	*In order to respond "Yes,"* the taxon must have been grown deliberately for at least 20 generations, or is known to be easily reared in captivity (e.g., fish farms, aquaria, or garden ponds). *Whereas, if the taxon has been subjected to substantial human selection that has led to reduced fitness and/or adaptability, then the response should be "No" despite the species being widely domesticated/cultivated.*
1.02 (C)	2	CL, E	Has the species *established self-sustaining populations* where introduced?	The taxon must be known to have successfully established self-sustaining populations in at least one location outside its native range *for an extended period of time – this "extended period" is likely to be shorter for short-lived species and longer for longer lived species.*
1.03 (C)	3	E	Does the species have invasive races/varieties/sub-species?	This question emphasizes the invasiveness of domesticated species.
2. Climate and distribution				
2.01 (C)	4	CL, CM	*What is the level of matching between the species' reproductive tolerances and the climate of the RA area*?	*The intention of this question is to assess the likelihood of a taxon establishing self-sustaining populations in the risk assessment area.* If readily available, then a climate matching approach (e.g., Climex, GARP, Climatch) may be used (see summary in Venette *et al.* 2010; BioScience 60: 349–362). *If a climate matching model is not available, then make a "best estimate" through consultation of the Köppen-Geiger climate region system (see: www.hydrol-earth-syst-sci-discuss.net/4/439/2007/hessd-4-439-2007.pdf) and/or local expertise.*
2.02 (C)	5	CL, CM	What is the quality of the climate match data?	*Quality' refers to the assessor's evaluation of the information used to determine the climate match.* If there are doubts about the quality of the information available, then attribute the minimum score (i.e., low).
2.03 (C)	6	CL, CM	*Does the species have self-sustaining populations in three or more (Köppen-Geiger) climate zones*?	Output from climate matching can help answer this, combined with the known versatility of the taxon as regards climate region distribution. Otherwise, the response should be based on natural occurrence in three or more distinct climate categories, as defined by *Köppen-Geiger (see: www.hydrol-earth-syst-sci-discuss.net/4/439/2007/hessd-4-439-2007.pdf), or based on knowledge of existing presence in areas of similar climate.*
2.04 (C)	7	CL	Is the species native to, *or established self-sustaining populations in*, regions with similar climates to the RA area?	*This issue raised by this question is whether or not the species actually is established in (or originates from) an area where the climate is similar to the risk assessment area.*
2.05 (C)	8	CL	Does the species have a history of being introduced outside its natural range?	Should be relatively well documented, with evidence of translocation and introduction. *A response of "Don't know" should be given where positive evidence is not available. A "No" response should be given if the taxon is a novel introduction of a single specimen.*

(*Continued*)

Table I. (*Continued*)

Section/(Code)	#	Criteria	Query	Guidance
3. Invasive elsewhere				
3.01 (C)	9	CL	Has the species *established one or more self-sustaining populations* beyond its native range?	*If uncertainty exists regarding the established, self-sustaining population(s), i.e., whether they constitute a true introduction/translocation or simply a "range expansion by natural means",* then the answer is "Don't know".
3.02 (N)	10	CL	In the species' *introduced* range, are there impacts to wild stocks of angling or commercial species?	There should be documented evidence of real impacts (i.e., decline of native species, disease introduction or transmission), not just circumstantial or opinion-based judgments.
3.03 (A)	11	CL	In the species' *introduced* range, are there impacts to aquacultural, aquarium or ornamental species?	*There should be documented evidence of real impacts (e.g., increased control costs, reduced yields), not just circumstantial or opinion-based judgements.*
3.04 (E)	12	CL	In the species' *introduced* range, are there impacts to rivers, lakes or amenity values?	Documented evidence that the species has altered the structure or function of a natural ecosystem.
3.05 (C)	13	CL	Does the species have invasive congeners?	One or more species within the genus are known *to exert moderate to severe impacts.*
B. Biology/Ecology				
4. Undesirable (or persistence) traits				
4.01 (C)	14	CL	Is the species poisonous/*venomous,* or poses other risks to human health?	Applicable if the taxon's presence is known, for any reason, to cause discomfort or pain to animals.
4.02 (C)	15	CL	Does the species out-compete with native species?	*There should be documented evidence that the taxon is responsible for* suppression of growth or survival, and/or displacement from microhabitat, of native species.
4.03 (C)	16	NC	Is the species parasitic of other species?	Needs at least some documentation of being a parasite of other species (e.g., scale or fin nipping such as known for *Pseudorasbora parva,* blood-sucking such as by some lampreys).
4.04 (A)	17	NC	Is the species unpalatable to, or lacking, natural predators?	This should be considered with respect to the likely level of ambient natural or human predation, if any.
4.05 (C)	18	E	Does species prey on a native species previously subjected to low (or no) predation?	There should be some evidence that the taxon is likely to establish in a hydrosystem *in which predatory fish have never been present, or* that is normally devoid of predatory fish *(e.g., amphibian ponds), or of a fish species that possesses a predation-facilitating biological attribute (e.g., behavior, large body size, appearance).*
4.06 (C)	19	CL	Does the species host, and/or is it a vector, for one or more recognized *nonnative infectious agents?*	The main concerns are nonnative pathogens and parasites, with the host either being the original introduction vector of the disease or as a host of the disease brought in by another taxon.
4.07 (N)	20	E	Does the species achieve a large ultimate body size *(i.e., > 15 cm total length)* (more likely to be abandoned)?	Although small-bodied fishes may be abandoned, large-bodied fishes are the major concern, as they soon outgrow their aquarium or garden pond.
4.08 (E)	21	CL	Does the species have a wide salinity tolerance or is euryhaline at some stage of its life cycle?	Presence in low salinity water bodies (e.g., Baltic Sea, *Tampa Bay*) does not constitute euryhaline, so minimum salinity level should be about 15%.
4.09 (E)	22	CL	Is the species *able to withstand being out of water for extended periods* (e.g., minimum of one or more hours)?	*Examples are lungfishes, walking catfishes, and species with desiccation tolerant eggs.*
4.10 (E)	23	NC	Is the species tolerant of a range of water velocity conditions (e.g., versatile in habitat use)?	Species that are known to persist in both standing and flowing waters over a wide range of velocities (0–0.7 m/sec).

(*Continued*)

Table I. (*Continued*)

Section/(Code)	#	Criteria	Query	Guidance
4.11 (E)	24	CL, E	Does feeding or other behaviors of the species reduce habitat quality for native species?	There should be evidence of *bioengineering behavior,* such as foraging that leads to *the destruction of macrophytes or* an increase in suspended solids, reducing water clarity (e.g., as demonstrated for common carp), *or burrow construction, which undermines bank character and stability (e.g., armored sailfin catfishes).*
4.12 (C)	25	NC	Does the species require minimum population size to maintain a viable population?	If evidence of population crash or extirpation because of low numbers (e.g., over exploitation or pollution), then response should be: "yes."
5. Feeding guild				
5.01 (E)	26	E	*If* the species *is mainly herbivorous or* piscivorous/carnivorous *(e.g., amphibia), then is its foraging likely to have an adverse impact in the RA area*?	*Obligate herbivores and* piscivores (as adults) are most likely to score here, *except where there is sufficient documented evidence form the RA area (or an area considered very similar) that the species has not exerted adverse impacts and therefore the appropriate response is "No." For a herbivorous species to score here, it must feed primarily on aquatic macrophytes.* In the case of some facultative piscivores, they may become more piscivorous when confronted with naïve prey.
5.02 (C)	27	E	*If* the species is an omnivore *(or a generalist predator), then is its foraging likely to have an adverse impact in the RA area*?	There must be evidence of foraging on a wide range of food types, including incidental piscivory. *For obligate piscivores (as adults) that go through ontogenetic dietary changes (e.g., from zooplankton to macrobenthos to fish), respond"'Yes" here, but then respond "No" to the next two questions.*
5.03 (C)	28	E	*If* the species is *mainly* planktivorous *or detritivorous or algivorous, then is its foraging likely to have an adverse impact in the RA area?*	Should be primarily planktivorous, *detritivorous, or algivorous* to score here. *For obligate piscivores (as adults) that go through ontogenetic dietary changes that include these food types (e.g., from zooplankton, to macrobenthos to fish), respond "No" here. Similarly, if there is sufficient documented evidence from the RA area (or an area considered very similar) that the species has not exerted adverse impacts, then the appropriate response is "No."*
5.04 (C)	29	E	*If* the species is *mainly* benthivorous, *then is its foraging likely to have an adverse impact in the RA area?*	Should be primarily benthivorous to score here. *For obligate piscivores (as adults) that go through ontogenetic dietary changes that include these food types (e.g., from zooplankton to macrobenthos to fish), respond "No" here.*
6. Reproduction				
6.01 (C)	30	CL	Does the species exhibit parental care and/or is it known to reduce age-at-maturity in response to environment?	Needs at least some documentation of expressing parental care, *including nest guarding, mouth brooding, live bearing, etc.*
6.02 (C)	31	CL	Does the species produce viable gametes?	*A "Yes" response requires evidence that the taxon produces viable gametes in the wild (native or introduced range). Functionally sterile hybrids, subspecies, or varieties receive a "No" response.*
6.03 (A)	32	NC	Does the species hybridize naturally with native species (or uses males of native species to activate eggs) in the RA area?	Consider evidence of hybrids, occurring in the RA area or elsewhere, with related taxa under natural conditions and without human assistance.
6.04 (C)	33	NC	Is the species hermaphroditic?	Needs at least some documentation of hermaphroditism.
6.05 (C)	34	NC	Is the species dependent on the presence of another species (or specific habitat features) to complete its life cycle?	Some species may require specialist incubators (e.g., unionid mussels used by *Rhodeus amarus*) or specific habitat features (e.g., fast-flowing water, particular species of plant or types of substrata) to reproduce successfully.

(*Continued*)

Table I. (*Continued*)

Section/(Code)	#	Criteria	Query	Guidance
6.06 (A)	35	CL, E	Is the species highly fecund (>10,000 eggs/kg), iteropatric or has an extended spawning season *relative to native species*?	Normally observed in medium-to-longer lived species.
6.07 (C)	36	NC	What is the species' known minimum generation time (in years)?	Time from hatching to full maturity (i.e., active reproduction, not just presence of gonads). Please specify the number of years.
7. Dispersal mechanisms				
7.01 (A)	37	CL	Are life stages likely to be dispersed unintentionally?	Unintentional dispersal resulting from human activity *(e.g., bait buckets, live eggs on anglers' gear)*.
7.02 (C)	38	CL	Are life stages likely to be dispersed intentionally by humans (and suitable habitats abundant nearby)?	Taxon has properties that make it attractive or desirable (e.g., as a food fish or an angling amenity, for ornament or unusual appearance, *for cultural reasons)*.
7.03 (A)	39	NC	Are life stages likely to be dispersed as a contaminant of commodities?	Taxon is associated with organisms likely to be sold commercially.
7.04 (C)	40	NC	Does natural dispersal occur as a function of egg dispersal?	There should be documented evidence that eggs are taken by water currents.
7.05 (E)	41	NC	Does natural dispersal occur as a function of dispersal of larvae (along linear and/or "stepping stone" habitats)?	There should be documented evidence that larvae enter, or are taken by, water currents, or can move between water bodies via connections.
7.06 (E)	42	CL	Are juveniles or adults of the species known to migrate (spawning, smolting, feeding)?	There should be documented evidence of migratory behavior, even at a small scale (*hundreds or thousands of meters*).
7.07 (C)	43	CL	Are eggs of the species known to be dispersed by other animals (externally)?	*There should be documented evidence of such movement events, e*.g., accidentally by waterfowl when they move from water body to water body.
7.08 (C)	44	NC	Is dispersal of the species density dependent?	There should be documented evidence of the taxon spreading out or dispersing when its population density increases.
8. Tolerance attributes				
8.01 (C)	45	NC	Any life stages likely to survive out of water transport?	There should be documented evidence of the taxon being able to survive for an extended period (e.g., an hour or more) out of water.
8.02 (C)	46	E	Does the species tolerate a wide range of water quality conditions, especially oxygen depletion and *temperature extremes*?	This is to identify taxa that can persist even in cases of low oxygen *and/or* elevated toxic levels of normal chemicals (e.g., ammonia) *and/or temperature extremes*.
8.03 (A)	47	CL	Is the species *readily* susceptible to piscicides *at the doses legally permitted for use in the risk assessment area?*	*To score a "no" response, there must be documented evidence of the taxon's resistance to chemical control agents at the doses legally permitted for use in the risk assessment area.*
8.04 (A)	48	E	Does the species tolerate or benefit from environmental disturbance?	Growth and spread of taxon may be enhanced by disruptions or unusual events (floods, spates, desiccation), *including both short- and long-term* human impacts.
8.05 (C)	49	CL, E	Are there effective natural enemies of the species present in the risk assessment area?	A known, effective, natural enemy of the taxon may or may not be present in the risk assessment area *(this includes infectious agents that would impede establishment). Unless a specific enemy (or enemies) is known, answer "Don't know."*

Note: Sector Codes (in parentheses) are: A = Aquaculture; E = Environmental; N = Nuisance; C = Combined. Criteria indicate the reason for making the change; CL = Clarity; CM = Climate, E = Ecological; NC = No Change.

climate questions and weights other questions related to impact and invasion history.[2] Climate models use data from terrestrial locations and may not be accurate for predicting water temperatures. Moreover, spatial gaps and differences in elevation between weather station locations and species occurrences may limit usefulness. The lower lethal temperature is often the most important environmental factor limiting the distribution and spread of nonnative tropical fish outside their native range, and this has been determined for several nonnative freshwater fishes in Florida.[27,28] We modified Qs 2.01–2.04 to allow the FISK assessor to respond to the climate matching section with high certainty without requiring climate matching software (see also Onikura *et al.*[9]) and opted to allow for the use of expert knowledge (e.g., laboratory-determined lower lethal temperature) or matching climate categories of the Köppen-Geiger climate maps.[29]

3.1.3. Invasive Elsewhere (Table I, Section A3)

A detailed and accurate account of a species' introduction and invasion history may be unavailable in popular databases as a result of poor data quality, e.g., limited or outdated collection data, species misidentifications, or conflicting reports.[30,31] Therefore, Qs 2.05–3.05 relating to invasive history were changed to allow assessor judgment in determining what constitutes reliable data detailing a nonnative species' introduction and status. For Q 3.05, the term "serious pest" is more commonly used to describe invasive plants[32] and was therefore changed to "known to exert moderate to severe impacts" because, by definition, an invasive aquatic species must be known to cause or likely to cause negative impacts.[33]

3.1.4. Undesirable (or Persistence) Traits (Table I, Section B4)

Minor modifications were made to the terminology used in Qs 4.01, 4.02, 4.06, 4.08, and 4.09. Q 4.06 was amended to include a "Yes" response for a species that may act as a novel predator in a new environment even where other predators are already present. For example, flathead catfish *Pylodictus olivaris* is a large-bodied piscivorous catfish. The introduction of flathead catfish into Georgia has been implicated in the decline of native bullhead *Ameiurus* spp. and redbreast sunfish *Lepomis auritus* populations, even though those species were not predator-naive.[34] For Q 4.07, the large body size categorization was increased from 10 to 15 cm total length (TL). Although fish whose ultimate body length exceeds 10 cm TL have an increased likelihood of being released, the majority of nonnative fish established in Florida typically reach an ultimate length > 15 cm TL.[35,36]

3.1.5. Feeding Guild (Table I, Section B5)

In FISK v1, species accrued an increase in score if categorized as a piscivore, omnivore, planktivore, or benthivore irrespective of whether the species' feeding strategy is associated with impacts within the risk assessment area. Therefore, a modifier was added to each of the feeding guild questions in FISK v1 (Qs 5.01–5.04), so that it is now explicitly stated that a species must have a feeding behavior that is "likely to cause an adverse impact in the RA (risk assessment) area" to receive a "Yes" response.

A "Yes" response for Q 5.01 is worth two points (more than the other feeding guild questions) because piscivorous fishes are often associated with impacts.[2,37] However, there was no similar consideration given for herbivorous fishes that primarily feed on aquatic macrophytes. In many tropical/subtropical environments, aquatic macrophytes are essential habitat features and herbivorous fish have the potential to alter this habitat with profound consequences for native species and ecosystem services. For example, the herbivorous grass carp *Ctenopharygodon idella* can cause dramatic changes to aquatic ecosystems.[38] Because of the magnitude of these potential impacts, we included herbivorous fishes in Q 5.01. In peninsular Florida, fishes that are primarily algivorous or detritivorous (e.g., blue tilapia *Oreochromis aureus* and Orinoco sailfin catfish *Pterygoplichthys multiradiatus*) have been successful in establishing populations; therefore, we included these categories in Q 5.03 to allow for the possibility of impacts within the risk assessment area for these types of fishes.

3.1.6. Reproduction, Dispersal, and Tolerance Attributes (Table I, Sections B6–8)

Q 6.01 was changed to include specific examples of parental care that are exhibited by fishes that have successfully established in Florida. The guidance for Q 6.02 now explicitly defines "produces viable gametes" and gives clear direction for assigning a "Yes" or "No" response.

Q 7.02 was amended to include "cultural releases" as an example of human-related dispersal of nonnative fishes. Cultural release is the suspected vector of introduction for multiple nonnative species,[39,40] including Asian swamp eels *Monopterus albus* in Florida.[41]

The terminology in Q 8.02 was changed from "high temperature" to "temperature extremes" because the lower temperature tolerance of some species (especially tropical fishes) is a limiting factor in their ability to establish and spread in new environments.[27] Q 8.03 was modified because virtually every species is susceptible to piscicides at high concentrations. However, some species are resistant to piscicides at legally permitted use levels or capable of limiting exposure because of behavior; these species should receive a response of "No." Chemical control agents are regulated differently in different regions and countries so no specific chemicals were listed.

3.2. *Software Improvements*

3.2.1. *Species Assessment Menu*

The new, improved interface of the *Species Assessment Menu* dialog was created (Fig. 1) with new features that include:

(1) Five additional columns, so that for each species in the list the following information is reported: (i) *Answered*: number of answered questions from the *Q&A* dialog out of the total set of 49 questions making up the FISK tool; (ii) *Score*: final, in case of a complete assessment, or partial otherwise; (iii) *U.K. (1; 19)*: risk level outcome (i.e., "Low," "Medium," "High") relative to U.K. calibration thresholds[3] (only upon completion of the assessment, that is, all 49 questions answered); (iv) *Japan (1; 19.8)*: same but relative to Japan calibration thresholds;[9] and (v) *U-D (–;–)*: same but relative to user-defined (UD) calibration thresholds.
(2) Possibility to *Edit* details of any species in the list, including its scientific and common name as well as the assessor's name.
(3) Possibility to *Delete* any species in the list.
(4) Indication of the *Total* number of species assessed and/or under assessment along with the number of species *Selected* for (multiple) report generation.
(5) Possibility to *Sort* (in ascending order) the species in the list *by* any of the eight columns therein (hence, excluding the unique species ID identifier).
(6) Possibility to set *UD thresholds* to distinguish between "Low," "Medium," and "High" risk species (e.g., as derived from a new calibration study).
(7) Ability to generate a *Report* for one or more species selected from the list. If the assessment has not been completed for any of the selected species, then the user is warned whether a report for that species is still required.

3.2.2. *Q&A*

The *Open Q&A* button in the *Species Assessment Menu* dialog opens up the *Q&A* dialog (Fig. 2). New features in this dialog include:

(1) A title bar indicating: (i) the question being answered, (ii) the species name, (iii) the common name, (iv) the assessor's name, and (v) the section and corresponding category for the question.
(2) A *Go to Question* combo-box control to move directly to any question in the assessment.
(3) A *Clear* button to erase all question information in the editable fields (i.e., Response, Certainty, and Justification).
(4) A *Close no Save* button to quit all changes being made to the species' assessment.
(5) Context-sensitive coloring, with the editable fields (as per above) marked in light green for answered questions, light red for unanswered questions, and light yellow for questions being answered.

3.3. Application

The FISK score for Barcoo grunter placed the species into the lower range of medium risk of being invasive (score = 5; Table II). Factors increasing the score included use in aquaculture, a climate match between its native range and peninsular Florida, broad climate suitability and tolerance of temperatures between 10 and 30 °C, parental care, and a likelihood for introduction and dispersal by humans. Barcoo grunter lacks a history of invasiveness and has few undesirable attributes, characteristics that increase FISK scores. Whereas a FISK score ≥19 would indicate unsuitability of a species for aquaponics, the medium risk score of Barcoo grunter

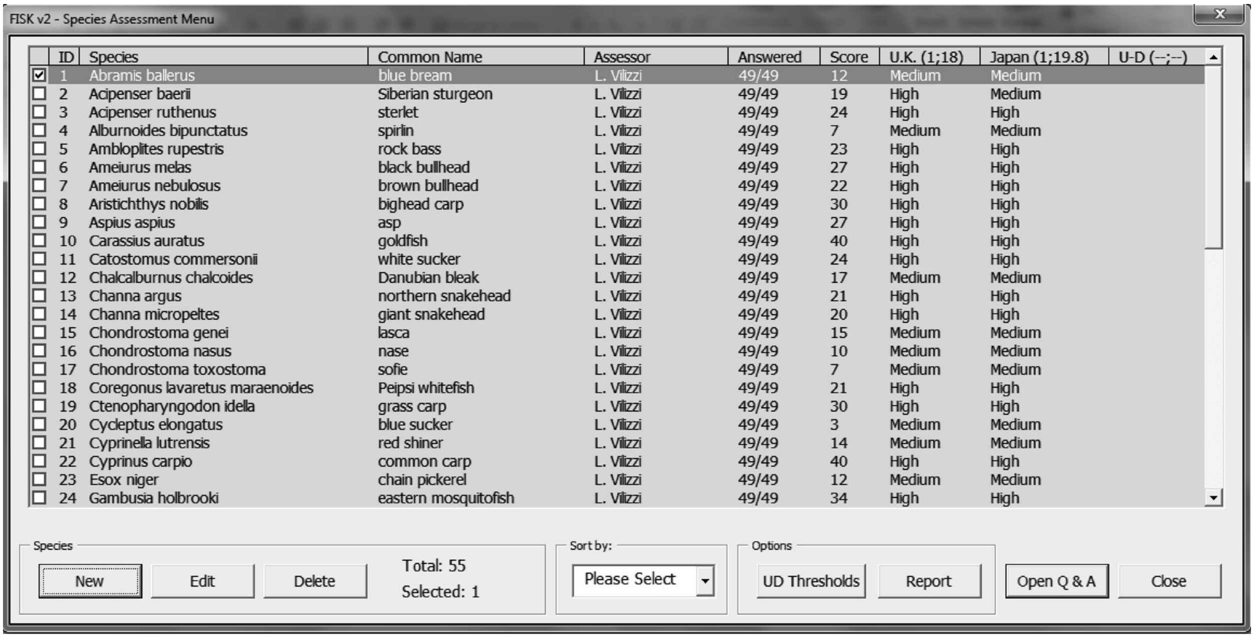

Fig. 1. New and improved interface of the *Species Assessment Menu* dialog in FISK v2 (data from Vilizzi and Copp[10]).

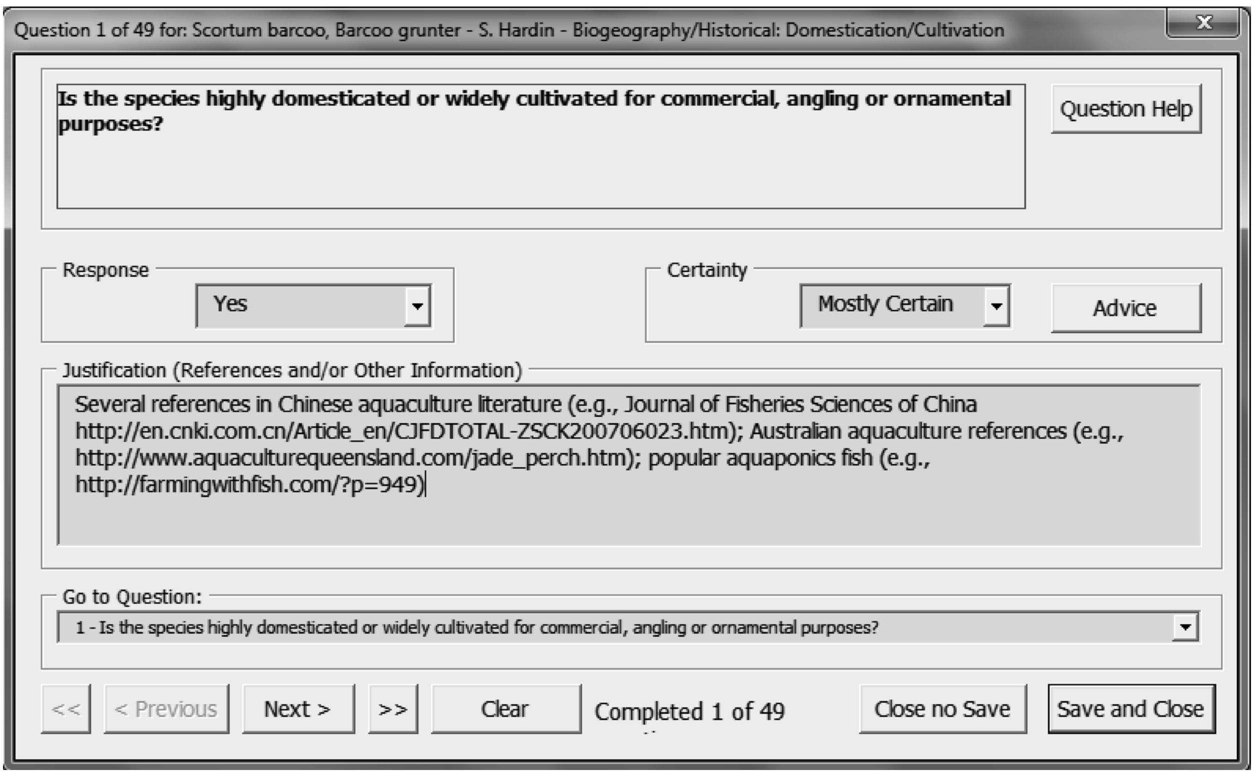

Fig. 2. New and improved interface of the *Q&A* dialog in FISK v2 (Q 1 for Barcoo grunter *Scortum barcoo*).

Table II. FISK v2 Protocol with Responses Given for Barcoo Grunter *Scortum barcoo* as a Real-World Application of FISK v2 in a Management Scenario

Species Name: *Scortum barcoo* Common Name: Barcoo grunter Assessor: S. Hardin				
Section/(Code)	Query	Response	Certainty	Comments and References
A. Biogeography/historical				
1. Domestication/cultivation				
1.01 (C)	Is the species highly domesticated or widely cultivated for commercial, angling or ornamental purposes?	Y	3	Several references in Chinese aquaculture literature (e.g., Journal of Fisheries Sciences of China; http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZSCK200706023.htm); Australian aquaculture references (e.g. http://www.aquaculturequeensland.com/jade_perch.htm); popular aquaponics fish (e.g. http://farmingwithfish.com/?p = 949).
1.02 (C)	Has the species established self-sustaining populations where introduced?	N	3	Only one introduction referenced in FishBase (China) with outcome unknown and presumably not established.
1.03 (C)	Does the species have invasive races/varieties/subspecies?	N	4	No subspecies listed in FishBase or ITIS (http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic = TSN&search_value = 168075).
2. Climate and distribution				
2.01 (C)	What is the level of matching between the species' reproductive tolerances and the climate of the RA area?	3	3	Native range in Australia from Northern Queensland and Northern Territory south to Lake Eyre drainage in central Australia (http://www.dpi.qld.gov.au/28_14677.htm); latitude is from 15°S–28°S (equivalent latitude is central Florida and south). FishBase lists temperature range as 10–30°C, but Chinese literature identifies lowest and highest critical temperature of embryonic development as 21°C and 31°C, respectively, and optimal temperature from 24–27°C (Chen *et al.* 2007).
2.02 (C)	What is the quality of the climate match data?	2	3	Match based on latitude and aquaculture research rather than water temperature data from native range.
2.03 (C)	Does the species have self-sustaining populations in three or more (Köppen-Geiger) climate zones?	Y	3	FishBase lists as temperate. Australian distribution covers 3 Köppen-Geiger zones; however, none of the three occur in Florida (map from Peel *et al.* 2007).
2.04 (C)	Is the species native to, or established self-sustaining populations in, regions with similar climates to the RA area?	Y	3	Native range has latitude distribution equivalent to central and southern Florida; temperature range in FishBase similar to portions of peninsular Florida (see earlier questions for references).
2.05 (C)	Does the species have a history of being introduced outside its natural range?	N	2	FishBase lists one introduction in China without documentation of establishment status. There has been considerable investigation into aquaculture of *S. barcoo* in China, which could be the source of the putative introduction.
3. Invasive elsewhere				
3.01 (C)	Has the species established one or more self-sustaining populations beyond its native range?	N	3	No reference to any established, introduced populations. FishBase reference to Chinese introduction without documentation.
3.02 (N)	In the species' introduced range, are there impacts to wild stocks of angling or commercial species?	N	3	The only reference to introduction (FishBase) has no data on establishment or ecological effects.
3.03 (A)	In the species' introduced range, are there impacts to aquacultural, aquarium, or ornamental species?	N	3	The only reference to introduction (FishBase) has no data on establishment or ecological effects.
3.04 (E)	In the species' introduced range, are there impacts to rivers, lakes, or amenity values?	N	3	The only reference to introduction (FishBase) has no data on establishment or ecological effects.
3.05 (C)	Does the species have invasive congeners?	N	4	Three congeners noted in FishBase (*S. hillei, S. neili*, and *S. parviceps*) with no reference to introductions.

(*Continued*)

Table II. (*Continued*)

Species Name: *Scortum barcoo* Common Name: Barcoo grunter Assessor: S. Hardin				
Section/(Code)	Query	Response	Certainty	Comments and References
B. Biology/ecology				
4. Undesirable (or persistence) traits				
4.01 (C)	Is the species poisonous/venomous, or poses other risks to human health?	N	4	FishBase status = Harmless. No references to venom.
4.02 (C)	Does the species outcompete with native species?	N	3	No documentation of ecological effects in the only introduction noted in FishBase. No other references located.
4.03 (C)	Is the species parasitic of other species?	N	4	No reference to this in FishBase or Australian summary (http://www.dpi.qld.gov.au/28_14677.htm).
4.04 (A)	Is the species unpalatable to, or lacking, natural predators?	N	3	Common length of 25 cm would make this species vulnerable to a host of medium to large piscivores, wading birds and crocodilians. Considering its value as a food fish, palatability is likely not an issue for non-human predators.
4.05 (C)	Does species prey on a native species previously subjected to low (or no) predation?	N	3	FishBase lists diet items as fishes, crustaceans, insects, and mollusks. In Florida, native predatory fishes occur in virtually every water body where these prey items are found.
4.06 (C)	Does the species host, and/or is it a vector, for one or more recognized non-native infectious agents?	N	3	No references found that address vectoring nonnative parasites and disease. Moreover, no data on the single introduction (China) listed in FishBase. Chinese aquaculture literature does not address this issue.
4.07 (N)	Does the species achieve a large ultimate body size (i.e., > 15 cm total length) (more likely to be abandoned)?	Y	4	Max size 35 cm, common size 25 cm (FishBase).
4.08 (E)	Does the species have a wide salinity tolerance or is euryhaline at some stage of its life cycle?	N	3	FishBase lists as freshwater; Appendix table to Australian fish distribution study lists as freshwater only (http://www.docstoc.com/docs/70966492/Appendix-I-Fish-species-distribution-abundance-and-trends-by-catchment).
4.09 (E)	Is the species able to withstand being out of water for extended periods (e.g., minimum of one or more hours)?	N	3	No references mention unusual desiccation tolerance.
4.10 (E)	Is the species tolerant of a range of water velocity conditions (e.g., versatile in habitat use)?	Y	3	Native to Gilbert River, which has the sixth-highest discharge of any river in Australia (Wikipedia); FishBase suggests that fish spawn during flooding.
4.11 (E)	Does feeding or other behaviors of the species reduce habitat quality for native species?	N	3	No evidence of bioengineering behavior.
4.12 (C)	Does the species require minimum population size to maintain a viable population?	?	1	No references found.
5. Feeding guild				
5.01 (E)	If the species is mainly herbivorous or piscivorous/carnivorous (e.g., amphibia), then is its foraging likely to have an adverse impact in the RA area?	N	3	Considered an omnivore by FishBase.
5.02 (C)	If the species is an omnivore (or a generalist predator), then is its foraging likely to have an adverse impact in the RA area?	N	3	FishBase lists as omnivore; food habits are similar to native Florida fishes and without novel predatory behavior or choice in habitats, impacts do not seem likely.
5.03 (C)	If the species is mainly planktivorous or detritivorous or algivorous, then is its foraging likely to have an adverse impact in the RA area?	N	4	Species is omnivorous (FishBase).

(*Continued*)

Table II. (*Continued*)

Species Name: *Scortum barcoo* Common Name: Barcoo grunter Assessor: S. Hardin				
Section/(Code)	Query	Response	Certainty	Comments and References
5.04 (C)	If the species is mainly benthivorous, then is its foraging likely to have an adverse impact in the RA area?	N	4	Species is omnivorous (FishBase).
6. Reproduction				
6.01 (C)	Does the species exhibit parental care and/or is it known to reduce age-at-maturity in response to environment?	Y	2	FishBase considers this a parental guarder, with males fanning eggs per Breder and Rosen (1966) Modes of Reproduction in Fishes. However, Chinese literature suggests that the egg is buoyant (Chen *et al.* 2007).
6.02 (C)	Does the species produce viable gametes?	Y	4	Reproducing population through much of Australia.
6.03 (A)	Does the species hybridize naturally with native species (or uses males of native species to activate eggs)?	N	4	No native congeners in Florida; Terapontidae is not native to Florida.
6.04 (C)	Is the species hermaphroditic?	N	4	No references to this were found.
6.05 (C)	Is the species dependent on the presence of another species (or specific habitat features) to complete its life cycle?	N	4	No references to this aspect of life cycle were found.
6.06 (A)	Is the species highly fecund (>10,000 eggs/kg), iteropatric or has an extended spawning season relative to native species?	?	2	Could not find references on fecundity; not listed in FishBase; Chinese and Australian aquaculture literature do not mention fecundity.
6.07 (C)	What is the species' known minimum generation time (in years)?	2	2	No references, but FishBase doubling time listed as 1.4–4.4 years.
7. Dispersal mechanisms				
7.01 (A)	Are life stages likely to be dispersed unintentionally?	N	3	Not a bait species; potential aquaponics species.
7.02 (C)	Are life stages likely to be dispersed intentionally by humans (and suitable habitats abundant nearby)?	Y	2	Potential as aquaponics food fish may lead to stocking; or discards from people who abandon aquaponics systems.
7.03 (A)	Are life stages likely to be dispersed as a contaminant of commodities?	N	3	Would be very unlikely to be sold with other fishes; very low probability as contaminant of non-fish commodities.
7.04 (C)	Does natural dispersal occur as a function of egg dispersal?	N	1	FishBase suggests parental care and pelagic eggs in same paragraph; however, as noted above, Chinese literature suggests floating eggs.
7.05 (E)	Does natural dispersal occur as a function of dispersal of larvae (along linear and/or "stepping stone" habitats)?	?	1	No literature or references found that address this.
7.06 (E)	Are juveniles or adults of the species known to migrate (spawning, smolting, feeding)?	?	1	Only reference is in FishBase which suggests this species may breed during flood events (Allen *et al.* (2002) Field Guide to the Freshwater Fishes of Australia). Unclear if migration is associated with this.
7.07 (C)	Are eggs of the species known to be dispersed by other animals (externally)?	N	3	No documentation, and unlikely if there is parental care or buoyant eggs.
7.08 (C)	Is dispersal of the species density dependent?	?	1	No references found that address stock densities in the wild.
8. Tolerance attributes				
8.01 (C)	Any life stages likely to survive out of water transport?	N	4	No references mention desiccation tolerance; not an air breather.
8.02 (C)	Does the species tolerate a wide range of water quality conditions, especially oxygen depletion and temperature extremes?	Y	2	FishBase lists temperature of 10–40°C, although aquaculture literature suggests fish are not active at temperatures below 20°C. Species does cover a relatively large portion of Australia.

(*Continued*)

Table II. (*Continued*)

Species Name: *Scortum barcoo* Common Name: Barcoo grunter Assessor: S. Hardin				
Section/(Code)	Query	Response	Certainty	Comments and References
8.03 (A)	Is the species readily susceptible to piscicides at the doses legally permitted for use in the risk assessment area?	Y	4	Rotenone or synthetic should be lethal at maximum label does (5 parts per million), which is allowable in Florida.
8.04 (A)	Does the species tolerate or benefit from environmental disturbance?	Y	2	FishBase reference to spawning during flooding; species adapted to turbid rivers, likely because of significant run off.
8.05 (C)	Are there effective natural enemies of the species present in the risk assessment area?	Y	3	Species does not exhibit unusual morphology or defensive behaviors. Would be subject to native predators.
Statistical summary of scoring	Outcome UK:	Medium		
	Outcome Japan:	Medium		
	Outcome User-defined:			
	Total score:	5.0		
Score partition:				
	A. Biogeography/historical:	4.0		
	1. Domestication/cultivation	1.0		
	2. Climate and distribution	2.0		
	3. Invasive elsewhere	1.0		
	B. Biology/ecology:	1.0		
	4. Undesirable traits	2.0		
	5. Feeding Guild	0.0		
	6. Reproduction	1.0		
	7. Dispersal mechanisms	–1.0		
	8. Persistence attributes	–1.0		
Questions answered				
	Total:	49		
	A. Biogeography/historical:	13		
	1. Domestication/cultivation	3		
	2. Climate and distribution	5		
	3. Invasive elsewhere	5		
	B. Biology/ecology:	36		
	4. Undesirable traits	12		
	5. Feeding guild	4		
	6. Reproduction	7		
	7. Dispersal mechanisms	8		
	8. Persistence attributes	5		
Sectors affected:				
	Aquacultural:	3		
	Environmental	7		
	Nuisance	1		
Certainty factor		0.73		

Sector Codes (in Parentheses) are: A = Aquaculture; E = Environmental; C = Combined. Scoring subroutines for "Climate matching" and "Invasive elsewhere," and "Generation time" are described in Copp *et al.* [2] and other responses are: Y = Yes; N = No; ? = Don't Know. Certainty values range from 1 = Very uncertain to 4 = Very certain.

suggests the need for further examination of the risk factors in Florida to determine whether mitigation (e.g., restrictions on location, system design, and development of best practices, as well as education and outreach) is required.

Barcoo grunter was assigned broad climate suitability based on an Australian reference,[42] where its distribution overlapped three Köppen-Geiger zones. However, there is uncertainty over the extent of the species' native range in Australia. Barcoo grunter probably is endemic to the Lake Eyre drainage, a large region in central Australia. Although commonly listed from northern regions draining into the Gulf of Carpentaria (e.g., Unmack[43]) these records likely are misidentifications of the gulf grunter *Scortum ogilbyi*.[44,45] The taxonomy of terapontids is difficult and confused. FishBase lists *S. ogilbyi* as a junior synonym of *S. hillii*, but *The Catalog of Fishes* lists *S. ogilbyi* as valid.[46] Davis *et al.*[47] recently used the name *S. ogilbyi* in ecological studies of terapontid fishes in northern Australia, and among the coauthors are noted experts on Australian fishes. Notably, Barcoo grunter is not included in the latter study even though the study area included the disputed range in Australia. Using the more conservative range distribution, Barcoo grunter would be found in only one Köppen-Geiger zone and its FISK score would be reduced. Furthermore, reproductive tolerance of Barcoo grunter was considered suited to Florida's climate based on comparable latitude and temperature tolerance. However, the Köppen-Geiger zone occupied by Barcoo grunter in Australia (BWh = arid, desert, hot) does not occur in Florida.

Parental care of eggs increased the FISK score, but the type of eggs laid by the Barcoo grunter is disputed in the literature. FishBase references Breder and Rosen's[48] review of reproductive modes in fishes and states that members of the genus *Scortum* have male parental care of eggs laid in a nest on the substratum. However, the FishBase account for the small-headed grunter *Scortum parviceps* contradicts itself by listing pelagic eggs and male parental care of the eggs in the same paragraph on *Biology*, also referencing Breder and Rosen[48] in the reproduction section.[49] This casts doubt on the validity of the FishBase information on *Scortum* reproduction. Recent aquaculture references in the Chinese literature describe the eggs of Barcoo grunter as free floating.[50] Other terapontids such as the silver perch *Bidyanus bidyanus* clearly lay semibuoyant, pelagic eggs.[51] Therefore, it is most likely that Barcoo grunter eggs also float or are semibuoyant, and that dispersal of this species occurs via this mechanism. An affirmative response to the FISK question on parental care of eggs was offset by a negative answer to a subsequent question regarding egg dispersal. Accordingly, subsequent reevaluation of these questions and responses did not have an appreciable impact on the total FISK score.

The Barcoo grunter has no clear history of invasiveness, an important trait in determining risk categorization in FISK. With the exception of limited translocations within Australia,[52] it is unclear whether or not the Barcoo grunter has been introduced into open waters outside of its native range. This species is listed as introduced into China, but no data are available on the year of introduction or population status,[53] casting doubt that the introduction was into open waters rather than simply an aquaculture transfer.

Two questions dealing with the likelihood of introduction and human-mediated dispersal influenced the Barcoo grunter's medium risk ranking. Species with an ultimate body size >15 cm are considered more likely to be abandoned by aquarium hobbyists (Q4.07; Section B4; Table I). Barcoo grunter's ultimate body size >15 cm resulted in a "Yes" response for Q4.07 even though larger fish are desirable for aquaponics, and it is unlikely that the Barcoo grunter cultured for food would be released. Similarly, it is doubtful that aquaponics operators would be motivated to introduce this species into public waters as a food source. However, there is a possibility of abandoning home aquaponics systems for a variety of reasons, which might lead to releasing fish into public waters. For this reason, a "Yes" response was given for Q7.02 relating to the likelihood of intentional human dispersal.

4. DISCUSSION

The upgrades and modifications have made FISK v2 more functional than its predecessor (FISK v1) in terms of its use as a practical tool for identifying potentially invasive fish, thus informing the decision-making and risk management process undertaken by regulatory agencies. FISK v2 incorporates a wider range of ecological and environmental characteristics that facilitate invasion on a broader scale of risk environments (i.e., temperate to tropical climates), making FISK v2 applicable to peninsular Florida as well as other warm temperate, subtropical, and, potentially, tropical climate zones. The changes made to questions and question guidance reduce ambiguity in the terminology while also allowing increased flexibility in assessor judgment where applicable (e.g., determining invasion history, climate matching, and evaluating impacts). Noteworthy upgrades were made to the FISK v2 user interface that improved its efficiency and reporting ability and provide the assessor a greater level of control during use.

Beyond the application to the Barcoo grunter in this study, FISK v2 is being used in two subtropical regions, namely, Florida (United States) and southeastern Australia. In the later study, Vilizzi and Copp[10] evaluated 55 species in the Murray-Darling Basin and compared the resulting scores for 53 of the species with those previously obtained (by LV) for the United Kingdom using FISK v1.[3] They found differences in scores between the two FISK versions, with the main difference because of methodological changes in the *Feeding Guild* questions (most species) and the question on ultimate body size (four species with TLs >10 cm but <15 cm), which led to lower scores. Other differences were mainly attributable to climate predictions that suggest Australia, unlike the United Kingdom, will be drier in the future.[54] An additional objective of the Vilizzi and Copp[10] study was to compare the risk categories from FISK v2 with those obtained from two Australian-based risk assessment protocols.[10] The authors recommended adoption of FISK v2 as Australia's reference screening tool based on a proven track record of the FISK tool in several countries and regions worldwide compared to screening approaches currently limited to Australia, its semiquantitative nature as well as its antipodean origin as an adaptation of the Australian WRA.[2]

The application of FISK v2 to Barcoo grunter represents the first of a more extensive application of this screening tool to assess 98 nonnative fishes for peninsular Florida (LLL, LV, JEH, SH, and GHC, unpublished data). Although the FISK score for Barcoo grunter falls into the medium risk category, the species' score is relatively low in that category. Responses to questions were compliant with the FISK guidance and reflected a risk-averse approach appropriate for a state conservation agency. Many FISK questions are quantitative, but judgment is required in some cases, e.g., source data quality, degree of climate match, and likelihood of introduction. Despite increasing use of Barcoo grunter in aquaculture, information in databases and the literature was conflicting or contradictory, even for basic concepts such as native range and reproduction. Moreover, data quality for invasion history was poor. These deficiencies increased uncertainty, affected answers to questions, and influenced the final score. The justification fields in the FISK summary, which detail the assessor's rationale and references, are valuable for subsequent review and interpretation by environmental managers. A strength of a risk identification (screening) phase is to point out gaps in knowledge that may require additional investigation in the literature, interaction with species experts, or original research, especially when evaluating a species that is classified as medium risk. The FISK evaluation of Barcoo grunter suggests that this species may be a suitable candidate for aquaponics in Florida and that restrictions on possession may not be necessary.

Variability in assessor judgment is undesirable in risk assessments, in that it may introduce subjectivity; however, in some cases human judgment may improve the quality of the assessment by buffering data deficiencies or inconsistencies.[55] Nevertheless, where data/information are lacking, such as for the Barcoo grunter, increased uncertainty may motivate environmental managers/decisionmakers to take a precautionary approach. Several responses in our Barcoo grunter screening would have changed if assessor judgment was not permitted. Alternatively, assessor subjectivity may also be introduced if the screening questions are not specific, clearly written, or require assessor interpretation. The changes made for FISK v2 have addressed these concerns by simultaneously improving clarity of the questions and providing the assessor with clearer guidance in selecting the appropriate responses while also allowing the assessor latitude in judging the quality of data and information available and responding accordingly.

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