

Citizen science and expert judgement: a cost-efficient combination to monitor and assess the invasiveness of non-indigenous fish escapees

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SUPPLEMENTARY MATERIAL

Figures:

Figure S1: Reporting of fish species associated with *S. aurata*. Data expressed in percentage of total validated reports.

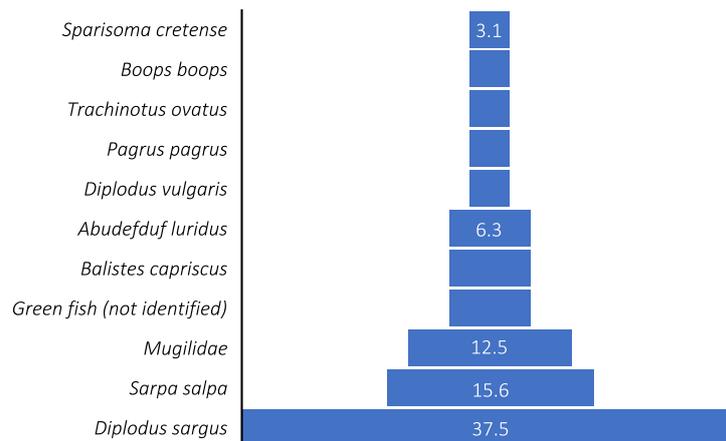


Figure S2: Sighting of *S. aurata* for each marine activity. (a) Sighting from SCUBA diving (b) sighting from recreational angling and, (c) sighting from spearfishing/freediving.

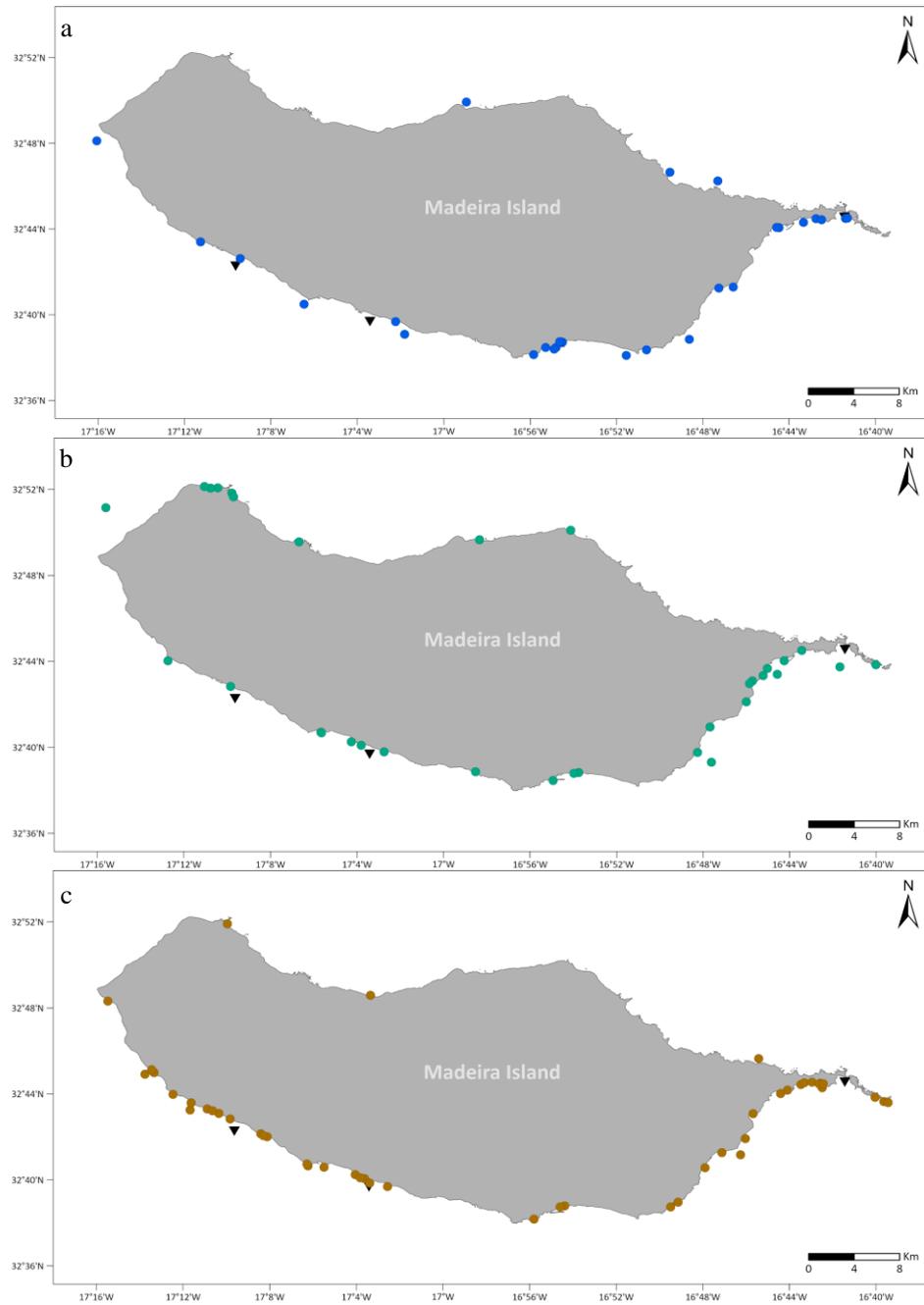
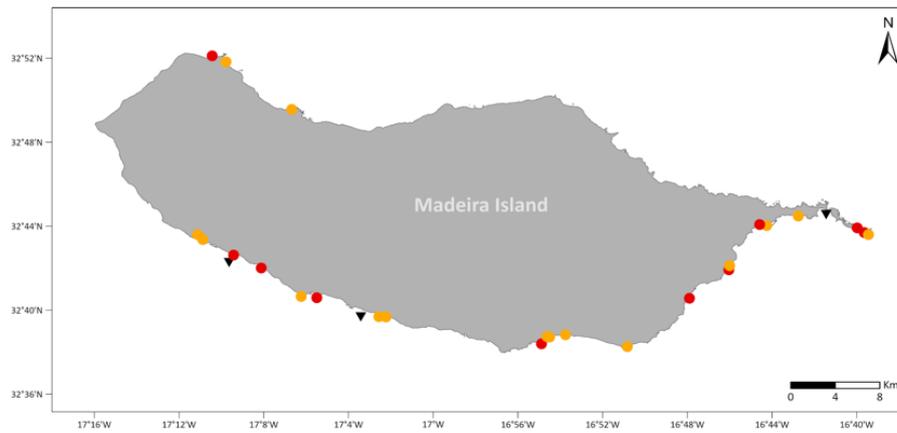


Figure S3: Sighting of *S. aurata* larger than 30 cm. Red represents sites where *S. aurata* larger than 30cm was always sighted while orange represents sites in which individuals larger than 30 cm were frequently seen. Black triangles are offshore aquaculture facilities.



Tables:

Frequency of sightings of <i>S. aurata</i> larger than 30 cm	Percentage of site
Always	9.6 %
Frequently	15.4%
Occasional	22.1%
Rare	38.5%
Never	14.4%

Table S1: Frequency of *S. aurata* individual bigger than 30 cm.

Place	Year	Number of contest/ number of contest with <i>S.aurada</i> caught									
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Agua de Pena		3/2	21/2	16/0	20/0	16/0	19/0	20/0	9/0	6/5	10/1
Canical-P. Natal		0/0	1/0	0/0	1/0	3/0	0/0	0/0	1/1	2/0	2/0
Funchal		1/1	2/1	3/0	1/1	0/0	0/0	1/0	0/0	2/1	2/0
Lugar de baixo		0/0	0/0	0/0	0/0	0/0	0/0	1/0	3/1	1/0	0/0

Machico	0/0	0/0	3/0	1/0	1/0	1/0	1/0	0/0	0/0	0/0
Madalena do mar	0/0	0/0	0/0	0/0	0/0	0/0	3/0	0/0	0/0	0/0
Paul do Mar	4/0	3/0	11/0	6/0	7/0	1/0	0/0	4/0	3/0	2/0
Ponta Delgada	4/0	0/0	0/0	1/0	1/0	0/0	1/0	1/0	0/0	0/0
Porto Moniz	2/0	2/0	1/0	3/0	1/0	2/0	1/0	1/0	5/6	3/0
Porto Novo	0/0	0/0	2/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
Praia Formosa	1/0	0/0	0/0	0/0	1/0	7/0	5/0	0/0	2/0	0/0
São Vicente	0/0	0/0	0/0	0/0	0/0	0/0	0/0	2/0	0/0	0/0
Seixal	0/0	0/0	0/0	1/0	1/0	1/0	1/0	1/0	1/0	0/0
Sta Cruz-P. Palmeiras	12/0	0/0	0/0	0/0	0/0	2/0	2/0	2/1	3/2	4/0
Total	27/3	29/3	36/0	34/1	33/0	31/0	34/0	28/3	25/14	23/1

Table S2: Fishing contests performed along Madeira coasts in the period between 2010-2019. Values represent the total number of contests performed/the number of contests in which *S. aurata* has been caught. Between 2010 and 2016, *S. aurata* was classified as “other species” so missing data in this period do not correspond to an absence of individuals caught.

Place	Average % <i>S. aurata</i>	n contest
Caniçal	3.04	1
Agua de Pena	7.35	1
Santa Cruz	5.18	1
Funchal	0.17	2
Lugar de Baixo	5.56	1
Porto Moniz	1.2	6

Table S3: Fishing contests performed along Madeira coasts in the period between 2017-2019. Values represent the average percentage of *S. aurata* individual caught and the corresponding number of contests.

	Assessor 1			Assessor 2			Assessor 3			Assessor 4			Assessor 5			Assessor 6			Assessor 7			
	Resp	Conf	Scores																			
A. Biogeography/ Historical			1			3			8			21			15			13			17	
1. Domestication/ Cultivation			2			0			4			2			4			2			2	
1 Has the taxon been the subject of domestication (or cultivation) for at least 20 generations?	Yes	High		Yes	Very high		Yes	Very high		Yes	Very high		Yes	Very high		Yes	Very high		Yes	Very high	No	Very High
2 Is the taxon harvested in the wild and likely to be sold or used in its live form?	Yes	High		No	Very high		Yes	Very high	Yes	Very High												
3 Does the taxon have invasive races, varieties, sub-taxa or congeners?	No	Medium		No	Very high		Yes	High		No	Very high		Yes	Very high		No	High		Yes	Very high	Yes	Very High
2. Climate, distribution and introduction risk			1			1			1			1			1			1			1	
4 How similar are the climatic conditions of the Risk Assessment (RA) area and the taxon's native range?	Medium	High		High	Very high		Medium	High		High	High		High	High		High	Very high		High	Very high	High	Very High
5 What is the quality of the climate matching data?	High	Very High		High	High		High	Medium		Medium	High		Medium	Medium		Medium	Medium		High	Very High	High	Very High
6 Is the taxon already present outside of captivity in the RA area?	Yes	Very high		Yes	Very high	Yes	Very High															
7 How many potential vectors could the taxon use to enter in the RA area?	One	Very high		One	Medium		One	Very high		One	Very high	One	Very High									

8	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	High	Yes	Medium	Yes	Very high	N.A.	Very high	Yes	High	Yes	Very high	Yes	Very High
3. Invasive elsewhere			-2		2		3		18		10		10		14
9	Has the taxon become naturalised (established viable populations) outside its native range?	No	Low	Yes	Low	Yes	Very high	Yes	Very high	Yes	Very high	Yes	Medium	No	Medium
10	In the taxon's introduced range, are there known adverse impacts to wild stocks or commercial taxa?	No	Medium	No	High	Yes	Very high	Yes	High	Yes	Medium	Yes	High	Yes	Low
11	In the taxon's introduced range, are there known adverse impacts to aquaculture?	No	Very High	No	Very high	No	Very high	Yes	Very high	Yes	Medium	No	Very high	Yes	Medium
12	In the taxon's introduced range, are there known adverse impacts to ecosystem services?	Yes	Medium	No	High	No	High	Yes	Very high	No	Medium	No	Medium	Yes	Medium
13	In the taxon's introduced range, are there known adverse socio-economic impacts?	No	Medium	No	Very high	No	High	Yes	Very high	No	Medium	Yes	Medium	Yes	Medium
B. Biology/Ecology			13		16		9		8		16		10		16
4. Undesirable (or persistence) traits			4		6		5		5		5		1		6
14	Is it likely that the taxon will be poisonous or pose other risks to human health?	No	Very high	No	Very high	No	Very high	No	Very high	No	High	No	Very high	No	Very High

15	Is it likely that the taxon will smother one or more native taxa (that are not threatened or protected)?	Yes	Medium	No	High	Yes	Low	Yes	Medium	N.A.	High	Yes	Medium	No	High
16	Are there any threatened or protected taxa that the non-native taxon would parasitise in the RA area?	No.	Very High	Yes	Medium	No	Very high	No	Low	No	Medium	No	High	No	High
17	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?	No	Medium	Yes	Medium	Yes	High	Yes	High	Yes	Medium	No	Low	Yes	High
18	Is the taxon likely to disrupt food-web structure/function in aquatic ecosystems if it has invaded or is likely to invade the RA area?	Yes	Medium	No	Medium	No	Low	No	Medium	Yes	Medium	No	Low	Yes	Medium
19	Is the taxon likely to exert adverse impacts on ecosystem services in the RA area?	No	Medium	Yes	Low	No	Low	No	Medium	No	Low	No	Medium	Yes	Low
20	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	High	Yes	Very high	No	Low	Yes	Very high	Yes	Low	No	Low	Yes	Medium
21	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?	No	Medium	Yes	Very high	Yes	Medium	No	Low	Yes	Medium	No	Low	No	Medium

22	Is it likely that the taxon will achieve a body size that will make it more likely to be released from captivity?	No	High	No	Very high	No	Very high	Yes	Very high	No	Medium	No	High	Yes	High
23	Is the taxon capable of sustaining itself in a range of water velocity conditions (e.g. versatile in habitat use)?	Yes	Very high	Yes	Very high	No	Low	No	Low	N.A.	Medium	Yes	High	Yes	High
24	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?	Yes	Medium	No	Very high	Yes	Low	No	Medium	No	Medium	No	High	No	Medium
25	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)?	No	Very High	No	Medium	Yes	Medium	Yes	Medium	Yes	Medium	No	Low	No	Medium
5. Resource exploitation				2		2		2		2		0		0	
26	Is the taxon likely to consume threatened or protected native taxa in the RA area?	No	Very High	No	Very high	No	High	No	Medium	No	Low	No	Low	No	Medium
27	Is the taxon likely to sequester food resources (including nutrients) to the detriment of native taxa in the RA area?	Yes	Low	Yes	Medium	Yes	High	Yes	Medium	Yes	High	No	Low	No	High
6. Reproduction				0		2		3		5		2		3	
28	Is the taxon likely to exhibit parental care and/or to reduce age-at-maturity in response to environmental conditions?	No	Very High	Yes	Very high	No	High	Yes	High	No	Medium	No	Medium	No	High

29	Is the taxon likely to produce viable gametes or propagules (in the RA area)?	No	High	Yes	Very high	Yes	Low	Yes	Low	Yes	High	Yes	Very high	No	Low
30	Is the taxon likely to hybridise naturally with native taxa?	No	Low	No	Very high	No	Low	No	Medium	No	Low	No	Medium	No	High
31	Is the taxon likely to be hermaphroditic or to display asexual reproduction?	No	Very high	No	Very high	Yes	High	Yes	Very high	Yes	Very high	Yes	Medium	Yes	Very High
32	Is the taxon dependent on the presence of another taxon (or specific habitat features) to complete its life cycle?	No	Very high	No	Medium	No	Very high	No	High	No	High	No	Very high	No	Medium
33	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	Very High	Yes	Medium	Yes	Very high	Yes	Very high	No	Medium	Yes	High	Yes	High
34	How many time units (days, months, years) does the taxon require to reach the age-at-first-reproduction?	2	High	2	Very high	2	High	1	High	2	High	2	Low	2	High
7.	Dispersal mechanisms		4		1		-2		-1		6		3		3
35	How many potential internal vectors/pathways could the taxon use to disperse within the RA area (with suitable habitats nearby)?	One	Very high	One	Very high	None	Very high	>1	Medium	>1	High	One	Very high	One	High

Will any of these vectors/pathways bring the taxon in close proximity to one or more protected areas (e.g. MCZ, MPA, SSSI)?	Yes	High	Yes	Very high	N.A.	Very high	Yes	High						
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	Very high	N.A.	Very high	No	Very high	No	Very high	No	Very high	No	Very high	No	Very High
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	High	Yes	Very high	No	High	No	High	Yes	High	Yes	High	Yes	High
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	High	Yes	Low	Yes	Low	No	High	Yes	Very high	Yes	Medium	Yes	High
Are older life stages of the taxon likely to migrate in the RA area for reproduction?	Yes	High	No	Low	Yes	Very high	No	High	Yes	Medium	Yes	Very high	Yes	Medium
Are propagules or eggs of the taxon likely to be dispersed in the RA area by other animals?	No	Low	No	Very high	No	High	No	High	Yes	Low	No	High	No	High
Is dispersal of the taxon along any of the vectors/pathways mentioned in the previous seven questions (7.01–7.07; i.e. both unintentional or intentional) likely to be rapid?	Yes	Very high	Yes	Very high	N.A.	Very high	Yes	High	Yes	Medium	Yes	Very high	Yes	Very High

43	Is dispersal of the taxon density dependent?	Yes	Medium	No	Medium	No	High	Yes	Medium	No	Medium	No	Low	No	Medium
8. Tolerance attributes		3		5		1		-3		1		3		5	
44	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	Very high	No	Very high	No	High	No	Very high	No	Very high	No	Very high	No	Very High
45	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	High	No	High	Yes	Very high	No	High	Yes	Medium	Yes	Low	Yes	High
46	Can the taxon be controlled or eradicated in the wild with chemical, biological, or other agents/means?	Yes	High	No	Very high	No	High	Yes	High	No	Medium	Yes	Low	No	Medium
47	Is the taxon likely to tolerate or benefit from environmental/human disturbance?	Yes	Very high	Yes	High	N.A.	Low	No	Low	No	Low	Yes	Medium	Yes	Low
48	Is the taxon able to tolerate salinity levels that are higher or lower than those found in its usual environment?	Yes	Very high	Yes	Very high	Yes	Very high	Yes	Very high	Yes	High	Yes	High	Yes	High
49	Are there effective natural enemies (predators) of the taxon present in the RA area?	Yes	Very high	No	Very high	Yes	Medium	Yes	Very high	Yes	Medium	Yes	Medium	Yes	High

C. Climate change	8	2	0	6	8	-2	-10
9. Climate change	8	2	0	6	8	-2	-10
50 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 Medium	No change High	No change Medium	No change Low	Increase Medium	No change Medium	No change Medium
51 Under the predicted future climatic conditions, are the risks of establishment posed by the taxon likely to increase, decrease or not change?	Increase Medium	Increase High	No change Medium	No change Low	No change Medium	No change Medium	Decrease Medium
52 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 High	Increase Very high	No change Very high	Increase Low	Increase Medium	No change Low	Decrease Medium
53 Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on biodiversity and/or ecological integrity/status?	Higher Medium	No change High	No change Medium	Higher Low	Higher Low	Lower Low	Lower Low
54 Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem structure and/or function?	Higher Medium	Lower Low	No change Low	Higher Low	Higher Low	Lower Low	Lower Low
55 Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem services/socio-economic factors?	No change Medium	No change Low	No change Medium	No change Low	No change Low	Higher Low	Lower Low
BRA	14	19	17	29	31	23	33

BRA+CCA	22	21	17	35	39	21	23
Confidence							
BRA+CCA	0.75	0.8	0.71	0.7	0.6	0.62	0.67
BRA	0.78	0.82	0.73	0.75	0.63	0.66	0.7
CCA	0.5	0.63	0.54	0.25	0.38	0.33	0.38

Table S4. AS-ISK results for *S. aurata* in Madeira Archipelago. This table summarize the results of the risk assessment conducted by 7 assessors using the AS-ISK tool kit. For each assessor is shown the response (resp), the confidence (conf) and the final score. At the end of the table are presented the Basic Risk Assessment (BRA) values, which are concerned with the biogeographical and biological aspects of the targeted species and the BRA+CCA values, which address the Climate Change Assessment (CCA). For BRA and CCA are also expressed the confidence values.