Predicting species distribution using FishBase, SeaLifeBase and AquaMaps

Christine Marie V. Casal, Kathleen Kesner-Reyes, Ma. Lourdes D. Palomares, Nicolas Bailly and Rainer Froese
FishBase Information and Research Group, Inc. (FIN)
Khush Hall, IRRI Campus, Los Baños, Laguna 4031, PHILIPPINES

FishBase (www.fishbase.org) and SeaLifeBase (www.sealifebase.org) are global biodiversity information systems which cover a wide range of information including the taxonomy, biology and geographic distribution of aquatic species, including tools created for the management of natural resources. Figure 1 shows the depth of the coverage of these information systems.

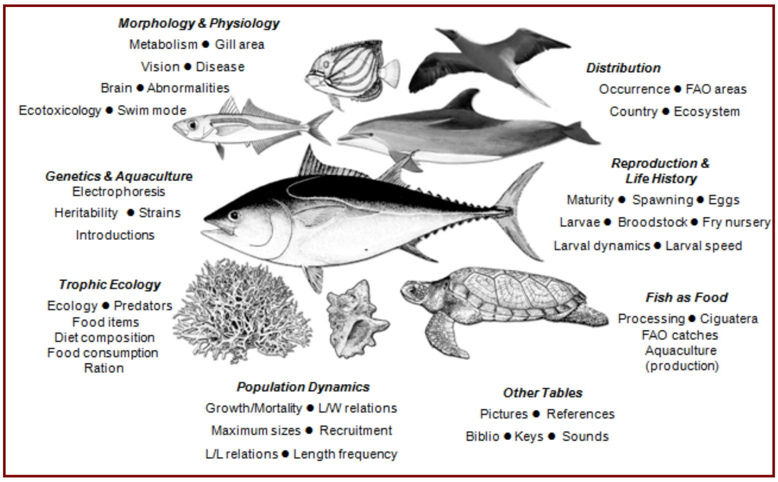


Figure 1. Coverage of FishBase and SeaLifeBase.

Within these information systems is an Introduction database where information regarding facilitated movement of species is documented. It is patterned after the DIAS (Database of Introduced Aquatic Species) of the FAO with whom we are in close collaboration.

Online reports/tools related to species introduction and invasiveness have been developed. Aside from the list of countries where a particular species has been introduced, a listing of species with reported adverse impacts (with the number of countries which reported the impacts) is included (Fig. 2). A list of species introduced in a given country is also available.

Introduced Species with Adverse Effects
[n = 42]
Sort by ○ Species ○ English name ◉ Number of Countries

SPECIES	ENGLISH NAME	NUMBER OF COUNTRIES that report adverse ecological effects
Oreochromis mossambicus	Mozambique tilapia	22
Oncorhynchus mykiss	Rainbow trout	22
Cyprinus carpio carpio	Common carp	22
Pterois volitans	Red lionfish	20
Oreochromis niloticus niloticus	Nile tilapia	16
Micropterus salmoides	Largemouth black bass	14
Salmo trutta trutta	Sea trout	13
Pseudorasbora parva	Stone moroko	12
Carassius auratus auratus	Goldfish	10
Lepomis gibbosus	Pumpkinseed	9
Gambusia affinis	Mosquitofish	9
Hypophthalmichthys molitrix	Silver carp	9
Poecilia reticulata	Guppy	8
Ameiurus melas	Black bullhead	8
Lepomis macrochirus	Bluegill	6
Neogobius melanostomus	Round goby	6
Clarias gariepinus	North African catfish	6
Esox lucius	Northern pike	5
Ctenopharyngodon idella	Grass carp	5
Clarias batrachus	Philippine catfish	5
Salvelinus fontinalis	Brook trout	5
Lates niloticus	Nile perch	4
Carassius gibelio	Prussian carp	4
Xiphophorus hellerii	Green swordtail	4
Odontesthes bonariensis	Argentinian silverside	4
Ameiurus nebulosus	Brown bullhead	4
Perca fluviatilis	European perch	3

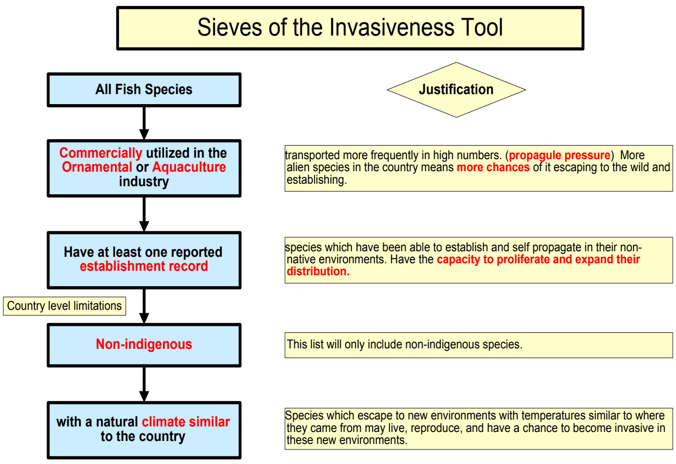


Figure 3. The Invasiveness Tool.

Figure 2. Fish species with reported adverse impacts after introduction

Our 'Invasiveness tool', predicts species establishment by country/island based on climate similarities, propagule pressure and recorded establishment in countries where they have been introduced. The premise of the tool is simple. A species which has commercial use in aquaculture and the ornamental industry is introduced in high numbers. The higher the number of species being brought in, the higher the risk of escapees. If a species is brought into a new environment with similar temperature regimes, it may establish. If a species has been able to establish and propagate in their non-native environments, they have the capacity to be able to proliferate and expand. Given the three conditions, a list is generated by the system. The list further incorporates the number of countries where the species has established and whether it has done so in the country being queried. A report generated from the database is provided (Fig. 4). The development of this tool is ongoing through the improvement and updating of biological and introduction information. Further development of the tool is also done by improving the sieves of the tool, i.e., inclusion of other biological information in the analyses. The link to the invasiveness report given on the FishBase site is provided (http://www.fishbase.org/country/InvasiveExotics.php?what=both&c_code=598A). By changing the country name and clicking refresh, the user is provided a list of potentially invasive species for the selected country.

Aquaculture and Aquarium Fishes Which May Establish Themselves in Philippines [n = 129]

List of commercial aquaculture and aquarium fishes which match the environmental conditions in Philippines, and which have established themselves in at least one other country.

Refresh ○ FB name ○ Species ○ Family ○ Aquaculture ○ Aquarium ○ Max. length ○ Productivity ● Other countries

Select: Philippines Percent established: 19%

FB name	Species	Family	Aquaculture	Aquarium	Max length (cm)	Temp. (°C)	Climate zone	Produc-tivity	Established in countries	
									This	Other
Mozambique tilapia	*Oreochromis mossambicus*	Cichlidae	commercial	commercial	39	17 - 35	tropical	Med.	Yes	110
Nile tilapia	*Oreochromis niloticus niloticus*	Cichlidae	commercial	never/rarely	60	14 - 33	tropical	Med.	Yes	69
Blue tilapia	*Oreochromis aureus*	Cichlidae	commercial	commercial	46	8 - 30	tropical	High	Yes	35
Redbreast tilapia	*Tilapia rendalli*	Cichlidae	commercial	commercial	45	24 - 28	tropical	Med.	No	28
Green swordtail	*Xiphophorus hellerii*	Poeciliidae	never/rarely	highly commercial	14	22 - 28	tropical	High	No	28
Redbelly tilapia	*Tilapia zillii*	Cichlidae	commercial	commercial	40	11 - 36	tropical	Med.	Yes	24
Longfin tilapia	*Oreochromis macrochir*	Cichlidae	commercial	never/rarely	43	18 - 35	tropical	High	No	20
-more info-	*Oreochromis urolepis hornorum*	Cichlidae	commercial	commercial	24	22 - 26	tropical	High	No	20
Southern platyfish	*Xiphophorus maculatus*	Poeciliidae	never/rarely	commercial	4	18 - 25	tropical	High	No	17
Jaguar guapote	*Parachromis managuensis*	Cichlidae	commercial	commercial	55	25 - 36	tropical	Med.	Yes	12
Giant gourami	*Osphronemus goramy*	Osphronemidae	commercial	commercial	70	20 - 30	tropical	Med.	Yes	11
Peacock cichlid	*Cichla ocellaris*	Cichlidae	commercial	commercial	74	24 - 27	tropical	High	No	9
Cachama	*Colossoma macropomum*	Characidae	commercial	public aquariums	108	22 - 28	tropical	Med.	Yes	8
Snakeskin gourami	*Trichogaster pectoralis*	Osphronemidae	commercial	highly commercial	25	23 - 28	tropical	Med.	Yes	8

Figure 4. Sample output of the Invasiveness Tool.

In keeping up with the spirit of cooperation and knowledge sharing, FishBase has created a species to species link to invasive species databases via individual species pages. These include the GISD, NAS, NOBANIS, CIESM, IABIN (on a per country level) and many others. This facilitates ease of access from FishBase to these databases and from these databases to FishBase. A sample is provided in Fig. 5.

Alien/Invasive Species Databases for *Oreochromis mossambicus*

[n= 9]

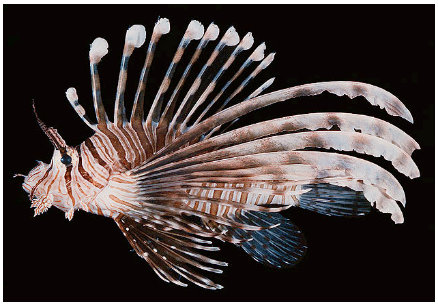
Name	Description
GISD	Global Invasive Species Database
USGS	Nonindigenous Aquatic Species
BASD	Brazilian Alien Species Database
NOBANIS	North European and Baltic Network on Invasive Alien Species
IABIN Jamaica	IABIN Jamaica
IABIN Ecuador	IABIN Ecuador
IABIN Columbia	IABIN Columbia
IABIN Brazil	IABIN Brazil
DIAS	FAO's Database on Introductions of Aquatic Species

Figure 5. Species-species links in FishBase.

These tools are currently available only in FishBase but in the future, similar tools will be developed for SeaLifeBase.

AquaMaps (www.aquamaps.org) is a species distribution modelling system for large-scale predictions of known natural occurrence of marine species (adapted from Kaschner et al. MEPS, 2006). It uses estimates of environmental tolerances (environmental envelopes) of a species derived from the integration of species habitat usage information in FishBase and SeaLifeBase, species occurrence data from GBIF, and a set of environmental parameters. Predictions are made by matching species tolerances against local environmental conditions to determine the suitability of an area for a given species. Probabilities of species occurrence are shown in color-coded species range maps (0.5° x 0.5° resolution). This modelling approach has been validated using independent survey data (Ready et al., Ecological Modelling, 2010). AquaMaps also uses modelled environmental conditions based on the IPCC A1B emission scenario to generate maps that predict potential shifts in species distribution by the year 2050 due to global climate change.

Combining biological information and geographic distribution of species (in FishBase and SeaLifeBase) allow for species-specific maps to be created in AquaMaps. Four types of maps are generated: Native range, All suitable habitat, Point map, and a Year 2050 scenario. A map of the Native range and the All suitable habitat maps for *Pterois volitans*, the Red Lionfish is provided (Fig. 7).

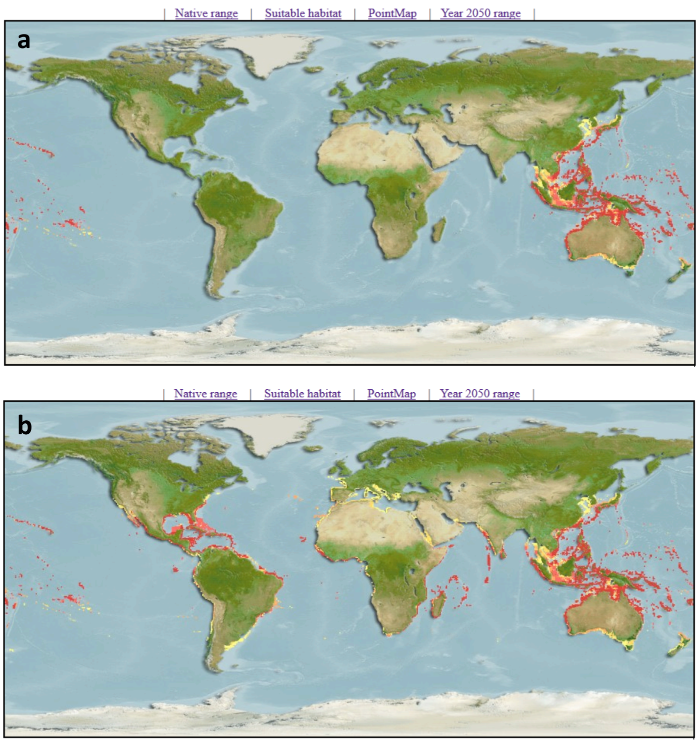


Distribution: Pacific Ocean: Cocos-Keeling Islands and Western Australia (Randall et al., 1997) in the eastern Indian Ocean to the Marquesas and Oeno (Pitcairn group), north to southern Japan and southern Korea, south to Lord Howe Island, northern New Zealand, and the Austral Islands. Replaced in the Indian Ocean by the very similar *Pterois miles* from the Red Sea to Sumatra.

Figure 6. Pterois volitans (photo by J. E. Randall).

The first documented release of the Red lionfish in Florida was in 1992. The sources of the fish may have been the six lionfish lost during Hurricane Andrew, deliberate releases from private aquarium keepers when the fish became too big for the aquarium, and small lionfish larvae which came in through ballast water of ships from the Indian or South Pacific oceans (O'Hanlon, 2002).

Currently, the population size of the species is small and may suggest minimal ecological impact. However if there would be an increase in population size they may significantly affect marine communities of Florida (Ruiz-Carus and Matheson, 2006).



Lately, it has been reported in the Bahamas, Bermuda, Jamaica and Puerto Rico as well (published references and Nicola Smith, a collaborator). The map in Fig. 7b shows that AquaMaps predicted that the species would likely establish in these countries once introduced.

Both FishBase and SeaLifeBase utilize AquaMaps not only for mapping native ranges but for predicting areas where they may establish once brought in through the ornamental trade, aquaculture or ballast water, among others.

Currently, the invasiveness tool can predict species establishment for commercial ornamental and

Figure 7. Pterois volitans (a) native range and all suitable habitat maps (b) from AquaMaps.

aquaculture species for both inland and marine fishes. AquaMaps provides a step forward in predicting marine species (both fish and non-fish) establishment through the identification of areas with similar conditions which are within a species' environmental tolerances.

Very little is known about movement of ballast water species especially in developing countries. This may be a powerful tool in the future with some more features built in. As the AquaMaps model is also being developed to estimate environmental tolerances of freshwater species, it may be utilized to predict inland species establishment as well. Keeping up with the voluminous information sources for improving the taxonomic, biological and geographical information in FishBase and SeaLifeBase represents tremendous and incessant tedious work, but the products that may be derived for the benefit of the public in the future far outweighs our current efforts.

Together, FishBase, SeaLifeBase and AquaMaps can be utilized to develop more powerful predictive tools for the aquatic ecosystems. We are looking forward to improve the information we currently have as well as create useful tools in collaboration with interested groups.

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Contact:

Dr. Christine Marie V. Casal (c.casal@fin.ph)

FishBase Information and Research Group, Inc.
IRRI Khush Hall, Los Baños, Laguna 4031, Philippines
T : +63.2.580.5659, +63.49.536.0168 , +63.49.536.2701 to 05