

The MarINvaders Toolkit

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DOI: [10.21105/joss.03410](https://doi.org/10.21105/joss.03410)

Software

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Submitted: 23 June 2021

Published: 25 June 2021

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Summary

The introduction and establishment of alien species to foreign ecosystems is a key threat for marine biodiversity ([Katsanevakis et al., 2014](#); [Molnar et al., 2008](#); [Seebens et al., 2017](#)).

Alien species are considered the most difficult to reverse pressure ([MEA, 2005](#)) and expected to increase in the near- and mid-term future ([Seebens et al., 2021](#)). Of particular concern are alien species which become established and out-compete local species on a large scale, thus becoming an invasive species. The Northern Pacific sea-star (*Asterias amurensis*) was, for example, introduced to Australia and Tasmania around the 1990's and since then became a major threat to endangered species in the Sea around Australia, as well as disrupting Australian aquaculture ([GISD, 2021](#)). Global research efforts to estimate the native distribution and alien introduction of marine species are spread over several databases. Principally, in combination these databases can be used to assess the native/alien status of a certain species or all species present in a marine ecoregion ([Spalding et al., 2007](#)) although they provide information with varying levels of resolution.

Statement of need

The largest databases for gathering information on marine species distributions are:

- The Ocean Biodiversity Information System ([OBIS, 2020](#)), which provides data on marine taxa and species distribution. It lacks information on the native range and alien range of species and how a specific species is affected by aliens.
- The World Register of Marine Species ([Horton et al., 2021](#)) contains information on native and alien species distributions.
- NatCon ([Molnar et al., 2008](#)) contains information on over 330 marine invasive species, including non-native distributions by marine ecoregion, invasion pathways, and ecological impact and other threat scores.

Additionally, the International Union for Conservation of Nature (IUCN) provides data regarding invasive species through:

- The Global Invasive Species Database ([GISD, 2021](#)). This is a freely accessible, online searchable source of information about alien and invasive species that negatively impact biodiversity.
- The IUCN Red List ("The IUCN Red List of Threatened Species," 2020). The Red List can be queried manually for information about which species are affected by invasives in their natural habitat.

36 The main challenge for cross-referencing these data sources is the varying geographic scale in
37 which alien and native species distributions are reported. Thus, there is a need for a tool that
38 automatically collects species data from all of these databases and harmonizes the distribution
39 data across the data sources. MarINvaders aims to close this method gap by providing a high-
40 level interface to assess the native and alien distribution of marine species on an individual
41 level as well as ecoregion level.

42 **Functionality**

43 MarINvaders consists of a Python 3 module that queries the open access databases listed
44 above for species data (sightings, threat levels and alien/native status) and also includes
45 copies of the databases which can not be queried online. When requesting information on a
46 specific marine ecoregion, the OBIS API (v3) is used to query all species for which there is
47 occurrence data within that ecoregion in the OBIS database. Each species is then searched
48 for in the other databases to potentially identify them as alien.

49 For WoRMS and OBIS data MarINvaders uses the API calls to request information on a
50 specific species or region. The NatCon database is included in the repository and provided
51 through the installation of the package. IUCN data (GISD and Red List) are not allowed to be
52 redistributed and also can not be queried automatically. We therefore made this data optional
53 for the use of MarINvaders and give a detailed description on how to obtain this data in the
54 documentation (https://marinvaders.gitlab.io/marinvaders/iucn_data/). Although this data
55 is not essential for using MarINvaders we recommend to add it as it provides additional data
56 on alien ranges (GISD) and allows to assess which species are affected by aliens (IUCN Red
57 list).

58 The databases provide geographical distributions on different scales. The NatCon distribu-
59 tions are on a marine ecoregion level. Most of the WoRMS distributions are either IHO Sea
60 Areas, Exclusive Economic Zones (EEZ), or an intersect of these, and have a Marine Regions
61 Geographic Identifier (MRGID) which is matched to a marine ecoregion by the use of shape-
62 files. GISD does not provide such MRGID's but instead gives quantitative distributions such
63 as country names. Most of these could still be matched to existing shape-files by matching
64 country/region names, and subsequently be matched to marine ecoregions. All the distri-
65 butions that could not automatically be matched were searched for manually and matched
66 to one or more marine ecoregions. The outcome of the manual matching is included in the
67 source code.

68 The result of a query through MarINvaders are various (Geo)pandas DataFrames which can
69 readily be used for subsequent analysis. In addition, MarINvaders provides several summary
70 statistics providing a overview of the alien/native species within an ecoregion as well as the
71 global distribution of a specific region separated into native and alien ranges.

72 **Outlook**

73 The MarINvaders toolkit is part of a larger effort within the ERC ATLANTIS project (<https://atlantis-erc.eu/>) which assess the impact of human activity on marine ecosystem. MarINvaders
74 will play a central role in upcoming case-studies and in the development of a web-platform for
75 assessing marine environmental impacts of human activity.
76

Acknowledgements

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 850717)

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