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A global database of intentionally deployed wrecks to serve as artificial reefs

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A B S T R A C T

This paper contains data on intentionally deployed wrecks from 1942 to 2016. The deployment of decommissioned vessels and other available wrecks is a common practice in many coastal countries, such as the USA, Australia, Malta, and New Zealand. We obtained data of georeferenced sites of wrecks from the scientific literature, local databases, and diving web sites published in the English language. Furthermore, we included information regarding the type of structure, location, depth, country, year of deployment and estimated life span. Moreover, we provide information on whether the wreck is located inside one of the World’s Protected Areas, key biophysical Standard Level Data from the World Ocean Database, distance to reefs from the Coral Trait Database, and distances to 597 aquariums that are members of the Species360 global network of Aquariums and Zoological institutions, in the Zoological Information Management System (ZIMS). We provide data for wrecks with monitoring surveys in the peer-review literature, although these only comprise 2% of the records (36 of 1907 wrecks). The data we provide here can be used for research and evaluation of already deployed reefs, especially if...
combined with additional spatial information on biodiversity and threats.

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### Specifications table

| Subject area                  | Biology                                                      |
|-------------------------------|--------------------------------------------------------------|
| More specific subject area    | Fisheries, artificial reefs, corals, aquariums, wrecks, conservation |
| Type of data                  | Tables, graphs, figures                                      |
| How data was acquired         | From published literature and websites in the English language |
| Data format                   | csv file, digitalized, standardized, and analysed data       |
| Experimental factors          | The data were compiled, digested and standardized from diverse sources, including local artificial reef databases, scientific publications, diving websites and the Species360’s ZIMS. We estimated age of wrecks based on the material from 39 studies. Associated key biophysical Standard Level Data and estimates of distances to the World Protected Areas and Aquariums |
| Experimental features         | We built the database in R based on currently available online data, including published literature and websites in the English language |
| Data source location          | The data include 34 countries globally.                    |
| Data accessibility            | The data will be placed in Species360’s Conservation Science Alliance data repository https://www.species360.org/serving-conservation/ship-wrecks-as-reefs/ |

### Value of the data

- A standardized database of worldwide intentionally deployed wrecks, from diverse information sources in a spatially explicit format including the type, material, year of deployment and estimates of the life span for each wreck.
- It can be used to analyse the potential of wrecks as artificial reefs under different conditions since each wreck’s record has associated key Standard Level Data, such as pH, chlorophyll A concentration, calcite, and sea surface temperature from the World Ocean Database [1].
- It can provide key information to assess the role of wrecks as artificial reefs to conserve marine biodiversity, because each wreck’s record is provided with the Euclidean distance with respect to: i) the Worlds Protected Areas [2], ii) the closest Coral Reef from the Coral Trait Database [3], and to each of the 597 aquariums member institution of the Species360 network [4].
- These data can help the prioritization of key areas for artificial reef monitoring or deployment.

### 1. Data

The data have a total of 1907 records from 88 sources (Table 1 [5]). Most of them (1739 or 91%) correspond to the USA locations, while the other 9% (168) were distributed around the rest of the world (Table 2 [6]). The majority of the wrecks (1118 or 71%) were vessels (Fig. 1). For 21% (408) of the records, we do not have information on the year of deployment. Of all the deployed wrecks’ analyzed worldwide, 1739 are from the USA (Table 2 [6]).
Sources of wrecks' location and depth. The sources include existing databases, diving guides and scientific publications.

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1.1. Distribution of wrecks in the USA

More than half of the wreck’s records (68%) in the USA are vessels. Subway cars/boxcars, automobile bodies, battle tanks, aircrafts, and submarines constitute the remaining 548 wrecks in the USA.
Fig. 1. Types of intentionally deployed vessels in the dataset. Colors indicate different types of vessels.

Fig. 2. Types of intentionally deployed wrecks in 12 of the American states.
data. Florida has the highest number of wreck records (43%). The dominant type of wreck data in all states, except Georgia and Alabama, was a vessel (Fig. 2 [5]). In Texas, North Carolina, California, Virginia and South Carolina more wrecks were sunk in the period before 1990 (Fig. 3 [6]).

1.2. Distribution of wrecks in the rest of the world

The data contain 168 wreck records distributed in 32 countries around the world (Tables S1 and 3, Fig. 4 [7]). Most of the deployed vessels (38% of the 168) are in Australia (Fig. 5 [2]).

Table 3
Number of deployed wrecks by country.

| Location            | Total | Dry bulk carrier | Dry cargo vessel | Fishing vessel | Land item | Other | Passenger ship | Service vessel | Special purpose vessel | Tanker | Warship | Yacht |
|---------------------|-------|------------------|------------------|----------------|-----------|-------|----------------|----------------|------------------------|--------|---------|-------|
| Argentina           | 1     | 0                | 0                | 1              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Australia           | 64    | 16               | 0                | 2              | 0         | 14    | 2              | 21             | 7                      | 0      | 1       | 1     |
| Barbados            | 1     | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Bermuda Island      | 1     | 0                | 0                | 0              | 0         | 0     | 0              | 1              | 0                      | 0      | 0       | 0     |
| Brazil              | 7     | 0                | 0                | 1              | 0         | 0     | 6              | 0              | 0                      | 0      | 0       | 0     |
| British Virgin Islands | 2   | 0                | 1                | 0              | 0         | 0     | 1              | 0              | 0                      | 0      | 0       | 0     |
| Canada              | 8     | 0                | 1                | 0              | 1         | 0     | 0              | 1              | 0                      | 0      | 5       | 0     |
| Cayman Islands      | 4     | 0                | 0                | 0              | 0         | 0     | 0              | 0              | 1                      | 0      | 0       | 3     |
| Cook Islands        | 1     | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Denmark             | 1     | 0                | 0                | 0              | 0         | 1     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Fiji                | 1     | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Great Britain       | 2     | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 1     |
| Grenada             | 1     | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Guadeloupe          | 1     | 0                | 0                | 0              | 0         | 0     | 0              | 0              | 1                      | 0      | 0       | 0     |
| Israel              | 1     | 0                | 0                | 0              | 0         | 0     | 0              | 0              | 0                      | 1      | 0       | 0     |
| Kenya               | 1     | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Malta               | 11    | 0                | 0                | 0              | 0         | 4     | 6              | 0              | 1                      | 0      | 0       | 0     |
| Mauritius           | 13    | 0                | 0                | 1              | 0         | 12    | 0              | 0              | 0                      | 0      | 0       | 0     |
| Mexico              | 2     | 0                | 0                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 2       | 0     |
| New                | 1      | 0                | 0                | 1              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Caledonia           | New   | 6                | 0                | 0              | 1         | 0     | 0              | 2              | 0                      | 0      | 3       | 0     |
| Portugal            | 4     | 0                | 0                | 0              | 0         | 0     | 2              | 0              | 0                      | 2      | 0       | 0     |
| Reunion             | 1     | 0                | 0                | 1              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Saint Helena        | 6      | 2                | 0                | 2              | 1         | 1     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Saint Lucia         | 2     | 0                | 0                | 0              | 0         | 0     | 0              | 0              | 2                      | 0      | 0       | 0     |
| South Africa        | 10     | 0                | 0                | 5              | 0         | 0     | 0              | 1              | 1                      | 0      | 3       | 0     |
| Spain               | 3     | 0                | 0                | 0              | 0         | 0     | 2              | 0              | 0                      | 1      | 0       | 0     |
| St. Eustasius Island | 2     | 0                | 0                | 1              | 0         | 0     | 0              | 1              | 0                      | 0      | 0       | 0     |
| Thailand            | 5     | 0                | 0                | 0              | 0         | 0     | 0              | 0              | 5                      | 0      | 0       | 0     |
| The Bahamas         | 1      | 0                | 1                | 0              | 0         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Trinidad and Tobago | 2     | 0                | 0                | 0              | 0         | 0     | 1              | 1              | 0                      | 0      | 0       | 0     |
| Turkey              | 1     | 0                | 0                | 0              | 1         | 0     | 0              | 0              | 0                      | 0      | 0       | 0     |
| Venezuela           | 1     | 0                | 0                | 0              | 0         | 1     | 0              | 0              | 0                      | 0      | 0       | 0     |
Fig. 3. Number of intentionally deployed wrecks by location and year.

Fig. 4. Global distribution of monitored and deployed wrecks, aquaria, coral reefs and marine protected areas.
2. Experimental Design, Materials and Methods

We compiled data of 1907 intentionally deployed wrecks to serve as artificial reefs from diverse sources, including local artificial reef databases, scientific publications, and diving websites (Table 1). Publications include scientific articles, monitoring reports, student theses and dissertations. The initial search for websites or publications with wrecks included mainly the use of the Google search engine, including Google Scholar and PubMed, with one or a combination of the following key words and expressions: shipwreck, artificial reef, sunken vessels, intentionally deployed. Later, we specified the search by adding a location, e.g., artificial reefs Europe, intentionally deployed vessels USA, shipwrecks as artificial reefs Australia, etc. Regarding wrecks located in the USA, the search was further specified using the key expression artificial reef with an addition of the particular state, e.g. artificial reefs Florida, artificial reefs Georgia, etc. In the majority of cases, the result of this search led to an official web page of the artificial reef program in the state in question. Furthermore, these web sites contained lists of all artificial reefs in the state. From these lists, we extracted information regarding only vessels and other types of wrecks. Regarding wrecks as artificial reefs in Australia, we used two main sources of information: 1) the Australian National Shipwreck Database [8], and 2) a report regarding sea dumping in Australia, prepared for the Australian Government, Department of Environment and Heritage [9]. We obtained data regarding wrecks as artificial reefs in the rest of the world from diving websites and scientific publications. We also gathered information about 1901 sites of wrecks of various types intentionally deployed globally as artificial reefs. The main fields included in the database were: name of the wreck and/or the reef site, year of deployment, type of wreck, location, coordinates, depth, accuracy of the coordinates (when provided), last update of the

Fig. 5. Comparison of the number of intentionally deployed wrecks globally, excluding the USA. The size of the circles is proportional to the number of sunken wrecks, with a minimum of 1 and maximum of 64.
Table 4
Description of the variables in the main dataset.

| ID | Description |
|----|-------------|
| Name | Name of the wreck |
| Year.of.deployment | Year of deployment |
| Type.of.wreck | High detail level of wreck category |
| Location.Country | Name of the country |
| Location.City.State.Province | Name of the City |
| Location.Water.Body | Name of the water bodies |
| Depth | Recorded depth of the wreck, in meters |
| Latitude | Latitude ISO 6709, in decimal degrees |
| Longitude | Longitude ISO 6709, in decimal degrees |
| Accuracy | Level of position accuracy |
| Last.update | Last wreck information update |
| Source | Internet reference link |
| Notes | Complementary information on the wreck location |
| ISO.Country.Code | ISO 3166, 3 characters code of country or territory |
| ISO.Country.Code.1 | ISO Numeric Code UN M49 Numerical Code |
| ISO.Country.Code.state.province. | ISO 3166, 3 characters code of country and province. |
| ID | Wreck ID |
| Wreck.Category | General category of the wreck |
| Protected.Area | Boolean value, 0 = not in a protected area, 1 = in a protected area |
| Name.Protected.Area | Name of the protected area |
| Near.Coral.ID | Identification of the nearest coral reef according to [3]. |
| Distance.Coral | Distance, in km, to the nearest coral reef. |
| Near.Aquarium.Name | Institution name of the nearest aquarium part of Species360 [4]. |
| Distance.Aquarium | Distance, in km, to the nearest aquarium. |
| Last.update.Year | Year of the last update |
| Last.update.Month | Month of the last update |
| Last.update.Day | Day of the last update |
| Purpose.of.deployment | Published purpose of the deployment |
| Method.of.sinking | Method of wreck sinking |
| Baseline.survey | Boolean value |
| Monitoring | Monitored parameters details |
| Method.of.monitoring | Monitored parameters method |
| Research.outcome | Result from monitoring |
| Life.span.years | Estimated lifespan of the wreck |
| Source.1 | Reference of the monitoring |
| Min.Est.Lifespan | Minimum estimated wreck lifespan |
| Max.Est.Lifespan | Maximum estimated wreck lifespan |

Table 5
Aggregated wreck categories, based on Knud E. Hansen*.

| Category | Example of artefact |
|----------|---------------------|
| passenger ship | ferry, passenger/cargo ship |
| dry cargo vessel | cargo ship, freighter, liberty ship |
| tanker | oil tanker, fuel barge, oil field supply vessel |
| dry bulk carrier | iron lighter, steel barge, wooden lighter |
| special purpose vessel | cable ship, buoy tender, cable layer vessel |
| service vessel | hydrographic ship, push boat, fireboat |
| fishing vessel | fishing trawler, clam boat, shrimp boat |
| off-shore vessel | submarine |
| yacht | yacht |
| land item | army tank, bus, aircraft, railroad boxcar |
| warship | destroyer, aircraft carrier, armoured personnel carrier |
| other | drydock, sailboat, powerboat, tour boat |

* Knud E. Hansen: [http://www.knudehansen.com/key-services/general-naval-architecture/vessel-types/](http://www.knudehansen.com/key-services/general-naval-architecture/vessel-types/)
information, source of the information and notes (Table 4). The coordinates were given in decimal degrees to allow the direct use of these data with other spatial information.

The data contain records of 130 types of wrecks, as described in the source, which we aggregated into 12 categories (Table 5). Each wreck record contains the citation, the latitude and longitude, the

| ID | Variable name (unit) | Original Spatial Resolution | Sensor | Data | Temporal range | Brief description |
|----|----------------------|-----------------------------|--------|------|----------------|------------------|
| calcite | Calcite concentration (mol/m³) | 5 arcmin (9.2 km) | Aqua-MODIS | Seasonal climatologies | 2002 - 2009 | Calcite concentration indicates the concentration of calcite (CaCO₃) in oceans |
| chlomax | Chlorophyll A concentration (mg/m³) | 5 arcmin (9.2 km) | Aqua-MODIS | Monthly climatologies | 2002–2009 | Chlorophyll A concentration indicates the concentration of photosynthetic pigment chlorophyll A (the most common “green” chlorophyll) in oceans. Please note that in shallow water these values may reflect any kind of autotrophic biomass. Mean value of chlorophyll Minimum value of chlorophyll Range of values of chlorophyll |
| chlomean | Mean value of chlorophyll | | | | |
| chlomin | Minimum value of chlorophyll | | | | |
| chlorange | Range of values of chlorophyll | | | | |
| cloudmax | Cloud fraction (%) | 6 arcmin (11 km) | Terra-MODIS | Monthly images | 2005–2010 | Maximum cloud fraction. It indicates how much of the earth is covered by clouds. Mean cloud fraction Minimum cloud fraction |
| cloudmean | Mean cloud fraction | | | | |
| cloudmin | Minimum cloud fraction | | | | |
| damax | Diffuse attenuation coefficient at 490 nm (m⁻¹) | 5 arcmin (9.2 km) | Aqua-MODIS | Monthly climatologies | 2002–2009 | The diffuse attenuation coefficient is an indicator of water clarity. It expresses how deeply visible light in the blue to the green region of the spectrum penetrates in to the water column. Mean diffuse attenuation coefficient Minimum diffuse attenuation coefficient |
| damean | Mean diffuse attenuation coefficient | | | | |
| damin | Minimum diffuse attenuation coefficient | | | | |
| parmax | Photosynthetically Available Radiation (Einstein/m²/day) | 5 arcmin (9.2 km) | SeaWiFS | Monthly climatologies | 1997–2009 | Photosynthetically Available Radiation (PAR) indicates the quantum energy flux from the Sun (in the spectral range 400–700 nm) reaching the ocean surface. Mean Photosynthetically Available Radiation (PAR) |
| parmean | Mean Photosynthetically Available Radiation (PAR) | | | | |
| sstmax | Sea Surface Temperature (°C) | 5 arcmin (9.2 km) | Aqua-MODIS | Monthly climatologies | 2002–2009 | Sea surface temperature is the temperature of the water at the ocean surface. This parameter indicates the temperature of the topmost meter of the ocean water column. Mean Sea surface temperature Minimum Sea surface temperature Range Sea surface temperature |
type of structure and the lifespan of the wreck to serve as an artificial reef (Table S1 & S2). We calculated the wrecks' lifespan based on the type of structure and material by using the estimates provided by 36 studies that monitor the colonization of the artificial reefs (see Table 1 for the source of those studies). For these 36 wrecks, we included the following information: estimates of lifespan as an artificial reef, purpose of deployment, method of sinking, baseline study before monitoring, the purpose of monitoring, the method of monitoring, and a brief summary of monitoring outcomes.

We extracted biophysical marine factors in each wreck location from Feldman & McClain [10] and from the World Ocean Database [1] (Table 6). This information includes key Standard Level Data, such as pH, chlorophyll A concentration, calcite, and sea surface temperature. We used ArcGIS version 10.5.1. [11] to:

i) Calculate the Euclidean distance between coral reefs and deployed wrecks by using the data on corals' location from the Coral Traits Database [3], which contain species-specific biogeographic locations (Fig. 6).

ii) Indicate if the wreck is located within a protected area, from the World Database on Protected Areas [2] (Table S1).

iii) Estimate the distance of wrecks to aquariums and zoological institutions members of Species360. The Species360 global network is a non-governmental organization that manages the Zoological Information Management System (ZIMS) [4]. ZIMS is a real-time database with standardized and shared information of 21000 species from more than 1100 zoos and aquariums institutions, of which 54% report having aquatic species (Fig. 7).

The data presented here do not cover all existing, deliberately sunken wrecks; the selection is based mainly on the availability of data either online or in publications in the English language. The quality and accuracy of the presented data entirely depend on the accurate, up-to-date information contained in the source documents. For quality control, we checked all data entries by at least one person who was not the main responsible for data input. For that, two people had access to the dataset at the same time: one person attributed a random record number to the other one, who was responsible to find the relevant data from the source person (such as: coordinates, name, year of deployment, depth). The two persons cross-referenced the data with the source to check for errors. To provide visualization of the data in the presented database we generated maps using ArcGIS [11].

![Fig. 6. Global distribution of coral reefs (orange dots), as reported in Madin et al. [3] and its distance from deployed wrecks in kilometers. Each blue and green colored dot represents a range of distance.](image-url)
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Transparency document. Supporting information

Transparency data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.12.023.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.12.023.

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