

**Best Practice Guidelines**  
in the Development and Maintenance of  
Regional Marine Species Checklists  
Version 1.0



**August 2012**

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<sup>1</sup> GBIF (2011). GBIF Strategic Plan 2012-16: Seizing the future. Copenhagen: Global Biodiversity Information Facility. 7pp. ISBN: 87-92020-18-6. Accessible at [http://links.gbif.org/sp2012\\_2016.pdf](http://links.gbif.org/sp2012_2016.pdf)

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## Preface

The Global Biodiversity Information Facility (GBIF) has released a [call for proposals](#) to develop a best practices guide in the development and maintenance of species checklists. GBIF's interest is for these practices to serve as a guide for future efforts to build and maintain species lists. A first guide applied to national checklists of terrestrial species, while the present document will cover checklists for regions and their marine species.

The compilation of any checklist of names includes four basic steps:

- obtain a definition for the geographic area to be covered
- define the taxonomic scope of the checklist
- compile authoritative lists of taxon distributions within this area
- validate the lists of names and update synonyms to currently accepted scientific names

But nothing will be simple, particularly when it comes to dealing with marine species. The following are some of the challenges when constructing checklists:

- **Sub-regions:** many regions may wish to have their checklist subdivided, for example, into east and west or north and south, or intertidal marine versus oceanic.
- **Frontiers:** countries will have checklists reaching past boundaries, notably for marine species.
- **Source:** information on taxon groups must be determined, originating from peer-reviewed publications to lists from biological surveys or citizen science activities.
- **Historical:** older reports may list species no longer present in an area.
- **Names:** similarly, older reports often contain taxonomic names that are no longer in use, due to revisions in the names (synonymy) or the classification hierarchy.
- **Georeferencing:** a source may provide general distribution information without clearly defining the area (e.g., giving a place name instead of a bounding box of spatial coordinates).
- **Notes:** it may be desirable to attribute notes to species names, such as introduced, invasive, pest, commercial value, seasonal, endangered, protected, vagrant, marine, freshwater.
- **Registers:** choosing a standard name list is required for resolving spelling variations and assigning the classification hierarchy.

- ***Orphans***: names not present in the accepted standard.

The Ocean Biogeographic Information System (OBIS) (Costello et al. 2007) would like to offer its assistance with the creation of the GBIF guidelines. OBIS is currently drafting a Node manager's guide for processing datasets. One section is dedicated to the standardization of species names and describes the process of matching names with accepted taxonomic standards. This taxon name matching process identifies spelling variations and also links older synonyms with accepted names.

The World Register of Marine Species (WoRMS) is the leading source of names for marine taxa (Appeltans et al. 2011) and is the taxonomic standard of OBIS. The WoRMS database design easily incorporates content from regional registers of marine species. These registers contain species distribution information for defined regions.

## Introduction

### Aim of this report

Technical guides and work plans for best practices in creating species checklists (e.g., GBIF 2011) are available from the GBIF online resource center (<http://www.gbif.org/orc/>). These reports explain how to make best use of the dataset standard using Darwin Core terms, presenting and publishing checklists under the framework of Darwin Core Archive (DwC-A), and by using the Integrated Publishing Tool (IPT).

The present document covers the more general aspects regarding checklists for marine regions. It outlines the steps required to compile distribution notes, to set up a register, and to produce a checklist, but also describes some of stumbling blocks that one might encounter along the way and offers suggestions on how to handle these issues.

### Setting up a business plan

Before undertaking the work of a checklist, a business plan should first be developed with the following ideas in mind:

- **Vision:** Explain why you are creating a checklist.
- **Mission Statement:** Explain what the checklist is about, what it does, and who the target groups are.
- **Timeline:** Detail the start date and foreseen end date (or dates for completion of the different phases).
- **Strategies:** What is needed to keep the checklist up-to-date, to make sure the data providers are active and that the checklist is used by the target audience?
- **Funds Required:** What budget and resources are required to keep the checklist up-to-date? Include a projection for at least one year.



## How to create a marine species checklist

### Part I: Building a list

A checklist is an authoritative list of taxa for a defined area. Content required to create these checklists should be archived in a database (to be called a register). To develop a checklist, the scope of the species register must be defined. The principal features of interest should be described, and they fall under the following headings:

- Taxonomic range
- Spatial range
- Temporal range
- Notes (attributes)

#### Taxonomic range

The taxonomic scope covered under a checklist usually refers to a subset of the taxonomic hierarchy (classification). In some instances, other species groupings may be desirable, such as by ecological function or habitat, or by sampling or observation techniques.

A subset of a taxonomic hierarchy may list members belonging to a particular taxon rank (e.g., class, order, or family). Common examples in the marine realm are checklists for fishes, polychaetes, crustaceans, echinoderms, or molluscs. These taxon group lists may provide more information or be easier to construct than a general list of all the species from a marine region. Thus, a workgroup may have an expertise in fishes, but not be concerned with invertebrates, nor have the means to evaluate their presence in detail. Likewise, polychaete specialists may not be equipped to consider fisheries observations for building a broader taxonomic checklist.

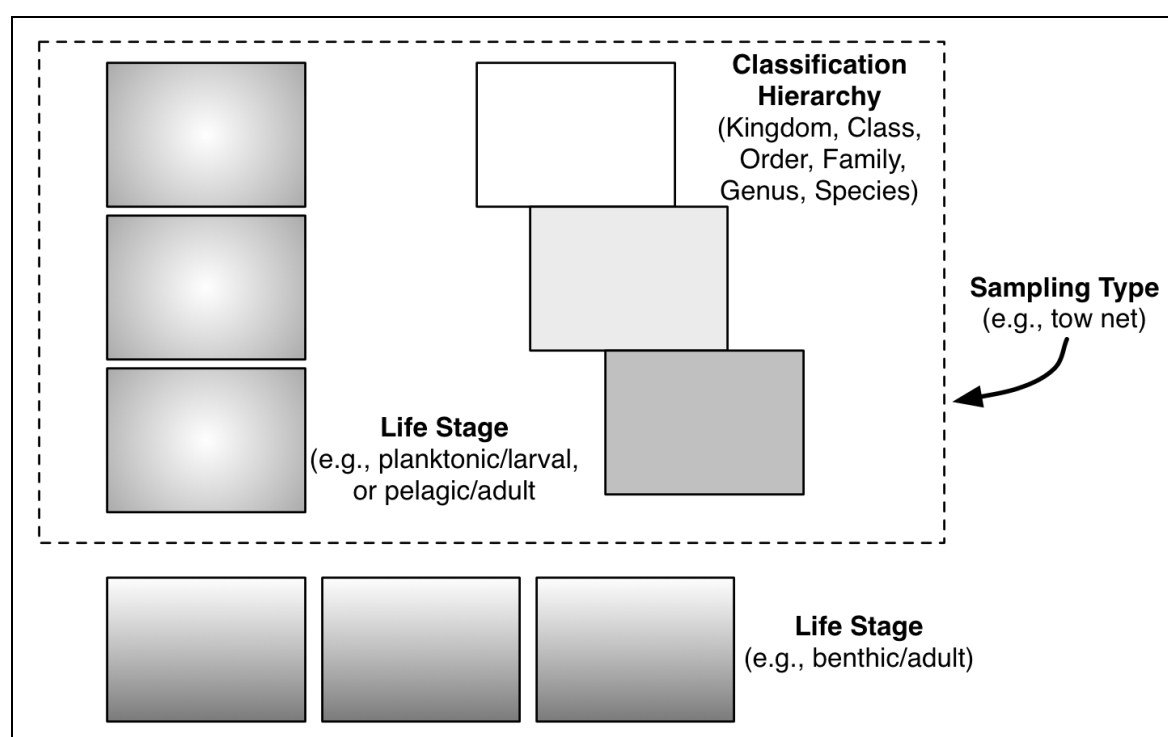
In marine work, it is often important to establish lists for functional groups, based on attributes beyond classification hierarchies (Fig. 1). A plankton grouping may comprise small organisms such as bacteria and viruses, or the larval, free-living stages of invertebrates and fishes (Li et al. 2011). A benthos grouping would also encompass a wide range of organisms, excluding the pelagic species and the planktonic life stages. Thus, a group describing a checklist of fishes may seek to effectively exclude larval (planktonic) stages of their targeted species. Likewise, reports of sessile (fixed) benthos may choose to ignore the presence of free-living planktonic stages.

Groupings of taxa may be also developed on the basis of survey techniques (Fig. 1).

Compared to terrestrial surveys of species, marine surveying is a costly and difficult

enterprise, and may need to be conducted remotely or through indirect means. Thus, checklists may be developed for water column sampling, sea bottom sampling, or underwater images. The effective constraints of the sampling or observation technique may thus define the scope of taxa that may be found in a list.

The purpose and extent of the taxonomic scope may be laid out when publishing a species checklist. Occasionally, with internal documents produced for a certain group or audience, it may be assumed the user is aware of the limits in species coverage. However, it is good practice to be explicit in taxonomic scoping when presenting checklists or other species compilations (e.g., Bourdages and Ouellet 2011). This will help new users who may be unfamiliar with the species, their ecology, and the methods involved in making the lists.



**Figure 1. Taxonomic scope defined as groupings by classification hierarchy, functional groupings (e.g., life stage), or survey technique (sampling type).**

## Spatial range

The spatial range of a checklist deals with the extent of the area to be examined. There are two main challenges in defining a spatial range for a marine list. The first is that most sources of information, such as historical observations and checklists, have varying degrees of precision in terms of geography. Thus, a taxon may be reported in a general manner, e.g., “Atlantic Ocean” or “France,” in which case the centre point (centroid on a continent) is not of much value for recording precise coordinates. In other cases, a locality (place name) may be reported with coordinates that are lacking in accuracy, due to

rounding errors or general value, e.g., if a record of 49° N, 60° W is entered to eight decimal places: 49.000000 N, 60.000000 W. These ambiguities represent difficulties in 1) establishing what records to include in a defined checklist and 2) choosing how to define a marine area.

Marine areas can appear arbitrary in extent or group association. It helps then to make use of an area definition from a recognized source, published in print or as an electronic resource. An area definition may be available as a text description, have coordinates, or have available spatial files such as Google Earth KML and ESRI shape files. Although the emphasis may be for terrestrial localities, marine area definitions are also available from global databases such as GeoNames (<http://www.geonames.org/>), the Getty Thesaurus of Geographic Names, (<http://www.getty.edu/research/tools/vocabularies/tgn/index.html>), or national resource centres, such as the Geographical Names Board of Canada database ([http://geonames.nrcan.gc.ca/index\\_e.php](http://geonames.nrcan.gc.ca/index_e.php)). Because of the gaps in large-scale databases, it may be useful to consult regional resources for more detailed and up-to-date spatial definitions. In Canada again, one example is the provincial Commission de toponymie Québec (<http://www.toponymie.gouv.qc.ca/ct/accueil.html>). These databases give spatial definitions of places, including marine features found in areas covered by surveys from that government.

For marine work, boundaries may be natural, arbitrary, or ill-defined. A natural boundary may be a sea, bay, or other semi-enclosed area. The definition does not have to follow political boundaries—it could be a fishing area (e.g., FAO, NAFO)<sup>2</sup>, an ocean or sea area (IHO)<sup>3</sup>, an ecosystem-defined area (e.g., MEOW, LME)<sup>4</sup>, or some convenient, albeit arbitrary, division of a region, such as north/south, west/east. Definitions of broader international areas may be consulted from marine data institutions, including ICES and NAFO in the North Atlantic. An important source of marine spatial definitions is the VLIZ Marine Gazetteer (VLIMAR) (<http://www.vliz.be/vmdcdata/vlimar/downloads.php>), hosted and maintained by the Flanders Marine Institute (VLIZ). In addition to listing information on well-known marine spatial areas, VLIMAR accepts reports defining any marine region. This makes it particularly useful as a standard resource for marine biogeography.

The principal resource for defining the marine scope is the General Bathymetric Chart of the Oceans (GEBCO). The GEBCO consortium of ocean mapping experts provides data products including an undersea features gazetteer of place names and bathymetric grids

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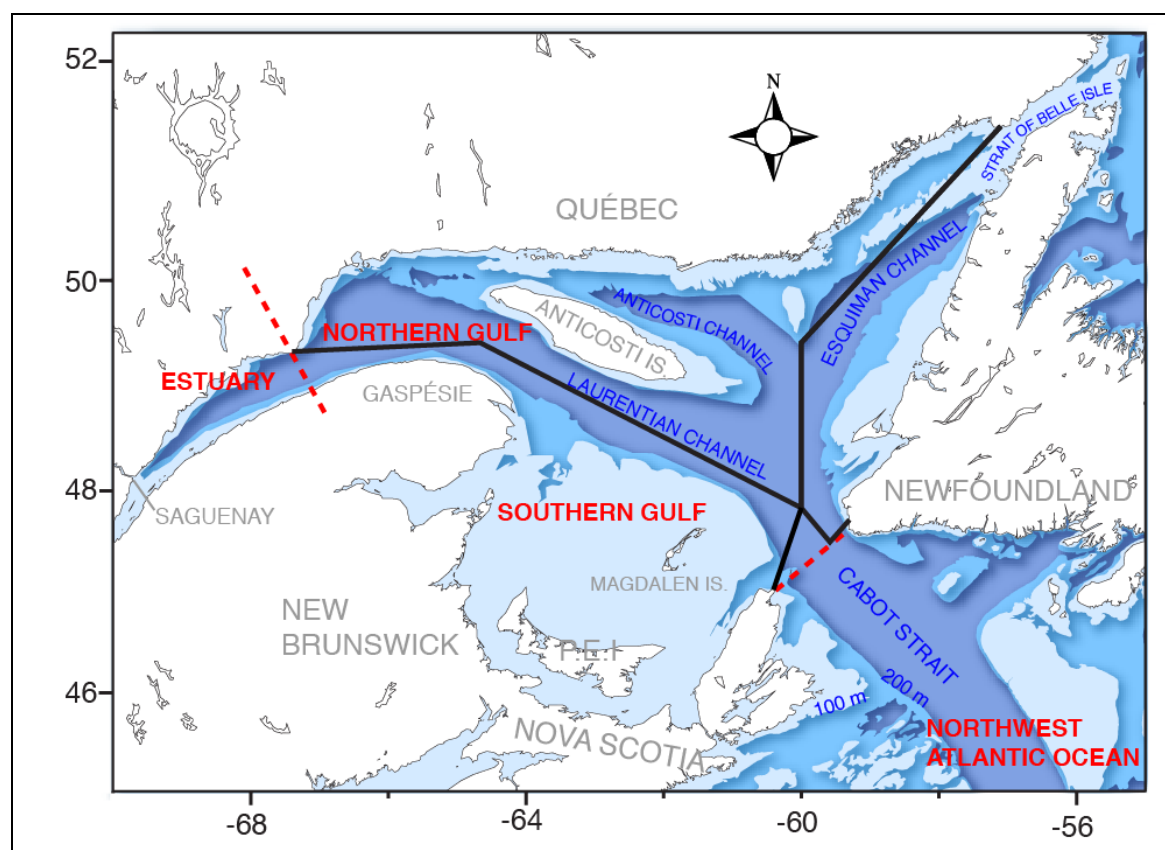
<sup>2</sup> FAO: Food and Agriculture Organization, NAFO: Northwest Atlantic Fisheries Organization

<sup>3</sup> IHO: International Hydrographic Organization

<sup>4</sup> LME: Large Marine Ecosystems of the World, MEOW: Marine Ecoregions of the World

as a digital atlas or paper charts (IOC, IHO, BODC 2003). The gazetteer can be downloaded ([http://www.gebco.net/data\\_and\\_products/undersea\\_feature\\_names/](http://www.gebco.net/data_and_products/undersea_feature_names/)) as a spreadsheet or a table. Of the 3,560 features in the latest version (August 2011), approximately 2,300 are already available in VLIMAR, with more additions to be added by VLIZ in 2012.

Similar to taxonomy, spatial scope may not need always be defined as part of a hierarchy, such as subregions and regions in a gazetteer. Marine systems may also be defined by functional groupings, for example, inshore and offshore areas. Inshore areas range from the intertidal to shelf-like marine areas. On the intertidal, some species may be encountered above the high-water mark. In some cases, scope should be defined by tidal level (e.g., low vs. high tide water marks) or submerged (e.g., mudflats, rock pools) vs. above water (e.g., dunes, sand bars). One also needs to draw a line between marine, brackish, and freshwater parts of estuaries, because the tidal impact sometimes reaches far into the freshwater area. On inshore shelves, areas may be defined by undersea features (bathymetric outlines) or water column (hydrographic) features such as currents. The Gulf of St. Lawrence in Canada can serve as an example (Fig. 2). This semi-enclosed sea may be delimited as a single body or as subregions based on hydrology and bathymetry from its channels and shelves.



**Figure 2. The Gulf of St. Lawrence as an example of delimiting a region and its sub-areas in terms of administrative zones (black lines: NAFO fishing divisions), bathymetric features (blue: channels and straits), and functional groupings (red lines: estuary, gulf, ocean).**

With offshore areas, broad features such as abyssal plains and shallow plateaus are punctuated by seamounts and canyons that may be difficult to resolve from global geographical sources. As with place names, agencies may need to work with regional groups or research institutes to obtain detailed information on local areas that may be unavailable from one-degree grids of global maps.

In some areas, defining regional boundaries may vary over time. While some are due to changes in barriers (e.g., temperature), other cases may be due to increased knowledge of species distributions relative to historical definitions (Mecklenburg et al. 2011).

### Temporal range

Species encountered in areas may change through time, which should be an additional consideration when building a checklist. Temporal scope may involve differences from the past, changes for the future, or the life history of organisms. In the first scenario, a present-day list may decide to exclude past species occurrences. This may be due to changes in species distribution or extirpations that have occurred since past surveys (Trott 2004a). Thus, taxa presently encountered adjacent to the defined area may be found within the area given favourable changes to their habitat distribution. In this situation, it may be desirable to define a scope for future changes in a checklist, for example, to include changes due to climate change and possible warming, with a subsequent spread of certain taxa to higher latitudes.

With the life history of taxa, their presence may depend on the season, or in some cases on extraordinary events such as blooms and species invasions or epidemics. Seasonality is a major feature in the presence of many marine animals, with fishes, birds, cetaceans, and pinnipeds undertaking long-distance migrations for feeding or reproduction during defined periods of the year. Life history also plays a role with some species that enter the marine environment at certain stages, commonly seen with fishes such as salmonids. Blooms are extraordinary reports of abundance, with the presence of taxa possibly seasonal or punctual and unique. Examples may be the bloom of planktonic algae in areas previously underreported or unknown with changes in hydrology due to freshwater runoff. Other events such as disease epidemics or competition from invasive species may change the number and types of taxa in an area compared to past lists. Two examples are 1) the disruption and re-emergence of marine eelgrass beds (*Zostera marina*) in the Northwest Atlantic over several decades (Short et al. 1987) and 2) the spread of the invasive green crab (*Carcinus maenas*) in Canadian waters (Klassen and Locke 2007). This last example may be a consideration for expanding or including extralimital or non-native species in a list, taking into account the shifts over time with the local ecology and habitat (e.g., shifts related to climate change).

## Notes or attributes

Several of the considerations described above for defining the scope are of a special nature. These considerations may be useful to note or flag in order to build a checklist, but also to adjust and build related checklists based on such flags for another set of taxonomic groups and area. The more common notes to add are attributes for distribution, habitat, life history, and ecology. **Distribution** notes are indicators of presence in the defined areas, while **Habitat** notes indicate the habitat type, such as intertidal, deepwater, pelagic, water column, or sea bed. **Life history** notes are important to flag species for their traits, ideally, as a combination between a life stage (larva to adult) and the “lifestyle” of that stage (e.g., benthic, sessile, planktonic, pelagic; Fig. 1). **Ecology** notes indicate attributes that have relations with other taxa, in particular invasive, bloom, parasite, or predator species.

The use of notes to add flags or attributes to taxa in a list will increase the value of checklists beyond a simple list of species occurring in certain places (Winston 1999). However, perhaps even more than with taxonomy and geography, the challenge will be to establish a standard manner of reporting and using notes, either as open text (comments) or a set of terms (controlled vocabulary). Several registers may provide defined lists of terms to use as a standard vocabulary, such as the Aquatic Sciences and Fisheries Abstracts (ASFA Thesaurus, <http://www4.fao.org/asfa/asfa.htm>). Recently, WoRMS and GeoHab have produced a glossary of standard terms for use in marine biology, ecology, and geology (Costello et al. 2010) (<http://www.marinespecies.org/glossary/>).

## Compiling names and associated notes

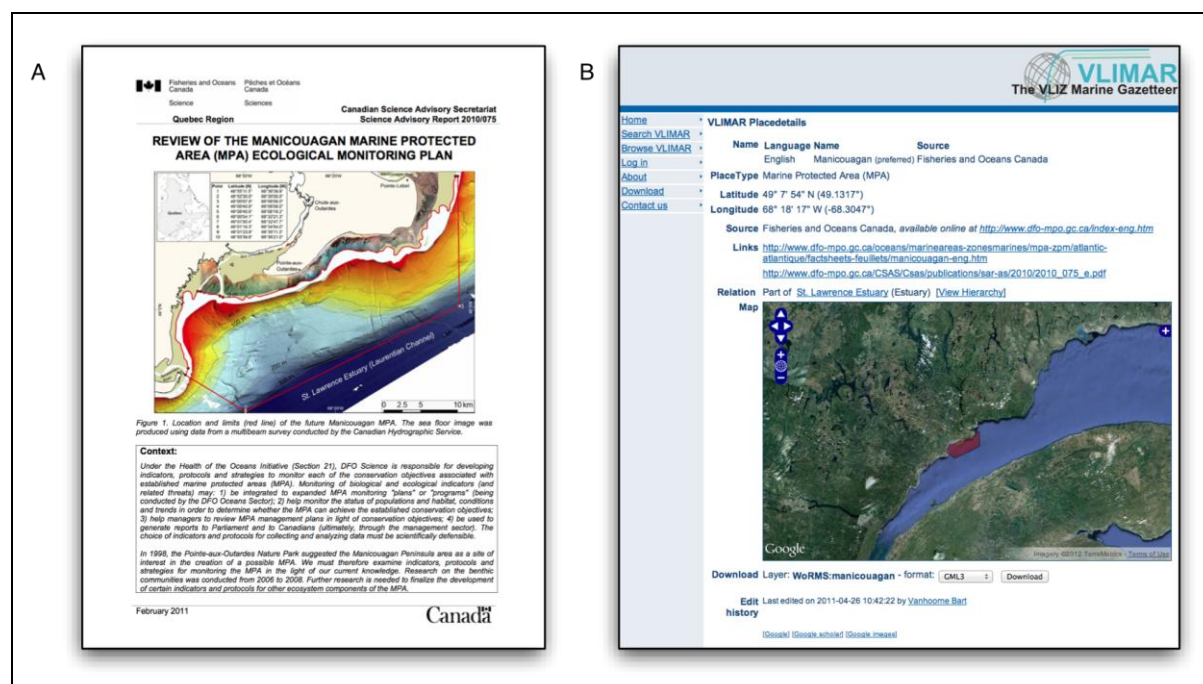
The **sources** of taxonomic names and notes used in the checklist should be documented. In most cases, this involves bibliographic research of print and electronic sources in primary publications and secondary sources including reports, theses, or non-published lists and documents (Winston 1999). The first sources to turn to may be web repositories such as the Biodiversity Heritage Library (BHL) (<http://www.biodiversity-library.org/>) and the complementary tools on the BioStor website (<http://biostor.org/>) to search documents for historical species lists. The WoRMS Literature Sources search webpage may also be used to obtain taxonomic sources. These initial sources may trigger a second search in linked sources or institutions, or their (online) resources.

### *Building a bibliography of sources*

Once literature has been compiled for the groups of interest, the discovered sources may be assigned flags by type, such as publication, expert opinion, or dataset. Publications are generally preferred for use as authoritative sources.

## Obtaining definitions for geographic areas

As introduced above under the heading of spatial scope, the principal sources for marine area definitions are the GEBCO atlas and the VLIMAR gazetteer. National hydrographic and charting agencies are additional providers, especially for local regions not yet listed in GEBCO or VLIMAR. In cases where the spatial coverage has been defined to overlap or include land areas, other agencies may be consulted to provide additional definitions. Conservation groups and government agencies may be sources to provide definitions attributed to marine protected areas, conservation zones, and marine reserves (Fig. 3). In many instances, these special areas will have spatial attributes available, usually as coordinate pairs, grid references, or shape files.



**Figure 3. Sources for marine area definitions. A) Government document published for a study area. B) Study area reported and made available in a marine gazetteer.**

## Part II: Reviewing information

### Adopting a taxonomic name standard

The compilation of source lists and other information will invariably reveal taxonomic names having different status and scientific authorship. Fortunately, the global biodiversity community has produced established standards to adopt when assigning names to taxa. Currently, three of the best-known standards are the Integrated Taxonomic Information System (ITIS), the Catalogue of Life (CoL), and the World Register of Marine Species (WoRMS). ITIS is well known as a standard for terrestrial and freshwater species, but their main focus is North America. Marine taxonomy is particularly challenging, and the advances made by taxonomic editors at WoRMS has lead to WoRMS being the recommended resource for marine species in databases such as OBIS, GBIF, EoL, FAO, SeaDataNet, IODE, and many others (<http://www.marinespecies.org/users.php>). For both of these standards, a unique code or serial number is associated with each taxon name, thus enabling the ability to match and compare between name versions. In the case of WoRMS, each taxon has its AphiaID and, when available, its associated TSN (the code from ITIS), and thus this register provides the names and codes from both of these taxonomic name standards.

### Reviewing species names and synonyms

The adoption of a taxonomic standard is followed by determining the appropriate taxon name, synonym, or version of a taxon name to be used in a checklist. Once a standard is adopted, it is possible to link synonyms to the associated and currently accepted taxon name.

For the new user, the concept of synonyms may be a confusing and frustrating exercise when consulting taxonomic standards. Firstly, after choosing a standard, it may be expected that only one name is available for use. On registers like ITIS and WoRMS, this name is flagged as *valid* or *accepted*. In some cases, the valid name has undergone further review and may be flagged as *verified* (ITIS) or *checked by Taxonomic Editor* (WoRMS). Other name versions, or synonyms, may be present in the standard registers. These variations include multiple descriptions of the same species (i.e., subjective/heterotypic synonyms) or historical spelling errors and name changes due to taxonomic revisions (i.e., objective/homotypic synonyms). These synonyms may be flagged as *unaccepted* or *invalid* (Fig. 4).



**WoRMS taxon details**

***Cancer magister* Dana, 1852**  
AphiaID: 452271

**Classification:** Biota > Animalia (Kingdom) > Arthropoda (Phylum) > Crustacea (Subphylum) > Malacostraca (Class) > Eumalacostraca (Subclass) > Eucarida (Superorder) > Decapoda (Order) > Pleocyemata (Suborder) > Brachyura (Infraorder) > Eubrachyura (Section) > Heterotremata (Subsection) > Cancroidea (Superfamily) > Cancridae (Family) > Cancer (Genus)

**Status** ✘ unaccepted

**Record status** Checked by Taxonomic Editor

**Accepted name** *Metacarcinus magister* (Dana, 1852)

**Rank** Species

**Type taxon of** *Metacarcinus* A. Milne-Edwards, 1862

**Parent** *Cancer* Linnaeus, 1758

**Source** Not documented

**Links**  
[To Barcode of Life \(20 barcodes\)](#)  
[To FAO Species fact sheets](#)  
[To USNM Invertebrate Zoology Decapod Collection](#)  
[To ITIS](#)

**Figure 4.** Excerpt of results using the taxonomic standard of WoRMS. A) Searched name. B) Standard code (AphiaID). C) Name status. D) Accepted name (currently valid name). E) Links to other global species resources.

An issue with names in historical lists may be the perception of competing values or authorities when these names undergo spelling or phylogenetic changes. However, the inclusion of standard codes makes it possible to continue to cite the older synonyms as it is linked to the currently accepted name. It is still important to record the names as they were published. This enables the reader to retrieve the information in the online resource and to correctly interpret the old literature.

## Using taxon matching tools

### *WoRMS Taxon Match Tool*

The correct spelling of a species name is not always trivial (e.g., which one is correct: *Cirrhitichthys*, *Cirrhitychthys* or *Cirritichthys*?), and it is very difficult for non-taxonomists to keep up with the valid status of species names. To help users in this situation, WoRMS offers a powerful, semi-automated name validation tool to crosscheck the spelling and taxonomic status of species against the WoRMS database.

The tool is an implementation of the new TAXAMATCH matching algorithm written by Tony Rees (CSIRO, Australia, <http://www.cmar.csiro.au/datacentre/taxamatch.htm>), which comprises a suite of custom filters and tests used in succession on genus, species epithet, plus authority where supplied. It also uses the Scientific Names Parser written by Dmitry Mozzherin.

The tool returns standard taxonomic information in a user-friendly format (e.g., MS Excel or tab delimited text file). The user needs to upload a list of species names and match the columns with the fields in the database. When there are multiple potential matches, the system provides a pick-list. The system will then return the file with the valid names (it corrects the spelling if there are close matches found and notifies when the name is an unaccepted synonym). Several related fields from the WoRMS database can also be selected to accompany the returned name file, including the authority and publication date, the hierarchical classification, quality status (expert validated or not), and the checklist globally unique identifiers (GUIDs).

It is a very popular tool already appreciated by thousands of users, with an average of 14 files uploaded daily. More information is available at:

<http://www.marinespecies.org/aphia.php?p=match>. Instructions to assist the user are documented in an online manual:

<http://www.marinespecies.org/tutorial/taxonmatch.php>

### Combining name matching tools

The WoRMS taxon match tool is highly effective for obtaining taxonomic codes and notes from lists of names. However, user intervention is required in case of 1) major spelling differences (it does capture one and two character differences and phonetic variations) and 2) ambiguities (potential homonyms with differing authorities) (Fig. 5).

**WoRMS Taxon match**

Match preview for the file 'test.xls' - matching: 83.33% [new match]  
If available, please select the WoRMS taxon that corresponds to your taxon. Then click 'Download'.

ScientificName	WoRMS match	Match type
Leptasterias polaris	Leptasterias (Hexasterias) polaris (Müller & Troschel, 1842)	exact
Poraniomorpha hispida	Poraniomorpha (Poraniomorpha) hispida (M. Sars, 1872)	exact
Thyone	(ambiguous – select below)	
Cucumaria frondosa	Cucumaria frondosa (Gunnerus, 1767)	exact
Cucumaria calcigera	Cucumaria calcigera (Stimpson, 18??)	exact
Brisater fragilis	(none)	

ScientificName	WoRMS match	Match type
Leptasterias polaris	Leptasterias (Hexasterias) polaris (Müller & Troschel, 1842)	exact
Poraniomorpha hispida	Poraniomorpha (Poraniomorpha) hispida (M. Sars, 1872)	exact
Thyone	(ambiguous – select below)	
Cucumaria frondosa	Thyone Oken, 1815 [exact]	exact
Cucumaria calcigera	Thyone Philippi, 1840 accepted as Porcellidium Claus, 1860 [exact]	exact
Brisater fragilis	(none)	

**spelling error** (red arrow pointing to 'Thyone')

**differing authors** (black arrow pointing to 'Thyone Oken, 1815 [exact]')

Figure 5. Example of user intervention to complete taxon matching with 1) spelling error and 2) ambiguous scientific names.

If no results are produced for spelling variations, the user will need to turn to alternative tools, either online or in print. Several web tools are currently available (April 2012) from ITIS, uBio, GNI, and IRMNG (Table 1). In case of doubt, the WoRMS data management team August 2012

can be contacted and the taxon name can be sent to the taxonomic editors for verification and possible addition to WoRMS.

Web tool	Comment
ITIS	Contains some marine synonyms not listed in WoRMS Covers freshwater aquatic species
uBio	Finds partial and whole names from several sources (ITIS, Zoobank, NCBI) Additional tools to parse texts for taxonomic terms, e.g., FindIT
GNI	<i>Global Names Index</i> : aggregator of principal scientific name repositories Additional tools to parse texts for taxonomic terms, e.g., Name Parser
IRMNG	<i>Interim Register of Marine and Nonmarine Genera</i> , by Tony Rees, CSIRO Searches by species and higher taxa levels, including partial names
BioStor	Aggregator web tool by Rod Page, University of Glasgow Facilitates searching BHL online texts for taxon names

**Table 1. Examples of complementary taxon name matching tools online in 2012.**

Print sources are good for revealing synonyms, both of valid names in the past (different classifications) and also of spelling variations, either deliberate (Latin naming rules, not phylogeny) or accidental (error). To discover these print sources, and as may have been the case in the initial search for lists of names, it may be useful to consult specialized species databases on the web and their bibliographies (Table 2).

Web tool	Taxa covered
AlgaeBase	Plantae, Chromista, Protozoa
Malacolog	Western Atlantic molluscs (shellfish) species database
Fishbase	Fishes, names and literature
Catalog of Fishes	Fishes, with review of names and literature
Hexacorallians of the World	Cnidarians (corals, sea anemones), with reviews of names, literature, distribution, environmental and other notes

**Table 2. Examples of specialized online resources for marine taxa references.**

### *Retaining synonyms of scientific names*

Upon completing the review of all scientific names in the initial species lists, the version containing the names as originally reported should be retained. In a spreadsheet, this could take the form of a list with the given name (including spelling errors), the name submitted to WoRMS, and the accepted version. Both submitted and accepted names will have corresponding AphiaID codes. Alternatively, and more commonly viewed in print, a final product of a checklist or catalogue of species may be to highlight the valid species term along with a listing of synonyms. More information on final list products is documented later in this report, but for illustrative purposes, two examples for marine species are shown below: the historical checklist of Cobscook Bay intertidal invertebrates by Trott (2004b) and the catalogue of St. Lawrence invertebrates by Brunel et al. 1998 (Fig. 6).

<p><b>A.</b></p> <p style="text-align: center;"><b>Subclass Alcyonaria</b></p> <p>Order Alcyonacea  Suborder Alcyoniina  Family Alcyoniidae  <i><b>Drifa glomerata</b></i> (Verrill,  1869)  <i>Drifa glomerata</i> Lr<sub>2</sub>, Lr<sub>3</sub>  <i><b>Gersemia rubiformis</b></i>  (Ehrenberg, 1834)  <i>Gersemia rubiformis</i> L,  P, R, USNM  <i>Gersemia carnea</i> V<sub>24</sub>  <i>Alcyonium carneum</i> Fl,  V, V<sub>6</sub>  <i>Alcyonium rubiforme</i> V<sub>6</sub>  <i>Eunephthya rubiformis</i>  Pe</p>	<p><b>B.</b></p> <p><b>19A : Alcyonacea</b></p> <p>Références taxonomiques générales : 83a, 270,  423, 980, 1062, 1570, 1595, 1596</p> <p><i>Duva florida</i> (Rathke, 1806) [?]  Régions : S, IPE  Étages/habitats : I, C  Réf. faunist. : 266, 456  Réf. taxon. : 83a, 423, 1570, 1596  Remarque : L'identification de ces spécimens  devrait être revue, à notre avis, compte tenu  de l'absence de monographies ou de  révisions récentes des Alcyonaires, et des  incertitudes affectant certaines  identifications des sources faunistiques qui  rapportent cette espèce, sous le nom de <i>Duva</i>  <i>multiflora</i>.</p> <p><i>Gersemia clavata</i> (Danielssen, 1887)  Régions : G  Étages/habitats : I?  Réf. faunist. : 1596</p>
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**Figure 6. Examples of species lists retaining alternate synonyms. A) Checklist by Trott (2004b), p. 274, showing historical synonyms along with the current name in bold type. B). Catalogue by Brunel et al. (1998), p. 73 listing a scientific name with its synonym in the notes or remarks (“Remarque”).**

### Obtaining vernacular names

Vernaculars, or common names, may be desired when compiling a species list. Certain groups, such as commercially important (fishing or aquaculture) species, will have a history of common names in the local or regional language. For these groups, lists of common names may be available. However, most species are only known by their scientific names, with no vernacular equivalent. In some cases, for regional databases, common names are “invented” or composed arbitrarily from the Latin binomial into a local language. As with taxonomic names, it is preferable to make use of an established standard for vernacular names. Global web tools such as FishBase, FAO, ITIS, and WoRMS are good sources. Regional variations of common names may be found in local publications. For example, the American Fisheries Society (AFS) publishes books with North American names, both common and scientific, for fishes, molluscs, and decapod crustaceans (e.g., Nelson et al. 2004). On a local scale, Brian Coad regularly publishes an online fish checklist including regional English and French Canadian common names (Coad 2011).

### Geographic names

For obtaining spatial definitions and place names, several resources were described in the first section. These resources will also be useful to verify the geography from given lists of species. If it is said that a species appears in a certain region based on literature, then it is equally important to check whether this is correct. This can be done by consulting field

experts. If the distribution is doubtful or proves to be wrong, this can be indicated; for example, in the WoRMS database, the distribution will be flagged as “invalid” (for more details see <http://www.marinespecies.org/tutorial.php - topic18>).

### *Reviewing geography*

Geo-referencing documents are often best when applied to terrestrial species. Marine species may have special challenges as to how their distribution is recorded in source lists. For example, sampling while at-sea may take place in a precise area, but the record is given with reference to the nearest land-based populated area—even if this is several dozen kilometres away. In these cases, using a gazetteer with place names can present problems if the given coordinates will result in land-based positioning. Such scenarios may be verified by projecting the spatial coordinates on a digital mapping tool such as Google Maps or Google Earth. For lists of coordinates, there are online mapping tools such as GPS Visualizer (<http://www.gpsvisualizer.com/>) and the marine-oriented GeoMapApp by the Lamont-Doherty Earth Observatory of Columbia University (<http://www.geomapapp.org/>).

While on-land places and coordinates may be obvious candidates for correction when they refer to marine species, some consideration may be necessary concerning how the record was obtained or recorded. Even if obvious to a taxonomic specialist, the erroneous distribution of species may not be evident to users when compiling long lists of dozen or even thousands of species names. Examples include 1) intertidal species that are not in error if projected spatially on a land area and 2) deep-sea species that are recorded with reference to a nearby coastal town. These cases reveal the value of notes and flags.

### *Creating distribution notes*

Distribution notes are comments associated with species names in the regional checklist. As with synonyms—because of the value of such notes when defining the members of the checklist—they are often given a special place when building the lists, either as a database table or a spreadsheet field. In the case of marine registers such as WoRMS, distribution notes are single terms for recognized marine place names (as defined in the VLIMAR gazetteer). However, having a name included in a defined marine area does not imply that the species is found everywhere in that area: it may be at its limit or a rare/transient resident.

### **Reviewing flags**

A number of characters are of interest to flag in a regional checklist. The definitions of these terms should go to a glossary. Preferably the flags will take the form of structured attributes (e.g., feeding types, or flags for marine vs. freshwater) as opposed to

unstructured notes (text comments). Some of the information conveyed by the notes may include the following:

- The first and last time the species was observed
- If the species is endemic to the region, at the boundary of its distribution, or widespread (so local protection is less urgent)
- If the species is common (abundant) or rare
- If the species has established populations and/or reproduces in the area
- If the species has known impacts on the local ecosystem
- If the species is commercially important (e.g., food, pharmacy, pest remediation, reef building, construction builder [corals], biofouling)
- If the species is vulnerable to certain marine activities (e.g., windmills, oil platforms, ship traffic)
- If the species has a local legal protection status
- The number of records currently contained in a global database such as OBIS.

## Part III: Maintaining a register

A species checklist is a final product based on compiled and maintained resources. Generating and updating such products is assisted with the use of spreadsheets and relational databases. The action of making such products is the result of work by assigned individuals. Provided there is a commitment of resources to maintain a register, a board of editors should be established that consists of taxonomic and data management experts. This is followed by work to ensure the updating, reception, and collaboration for species data. An example of the development of marine species registers is documented in the recent report by Van Guelpen and Kennedy (2011).

### Editors

The editorial board of a register consists of taxonomic and data management experts. Distribution records for names listed in the database have been, or are being, checked and updated by local taxonomic experts. In WoRMS, the editorial board of a regional checklist does not have direct authority to modify taxonomic information; however, the editors may collaborate with WoRMS taxonomic editors to effect changes. Duties to be performed by the editorial board include the following:

- reviewing unverified register records by assigning authoritative notes
- compiling distribution notes for areas of interest to scientists
- compiling taxonomic notes for taxa not included in the ITIS and/or WoRMS databases for unverified taxa and for taxa with out-of-date information
- compiling information associated with taxonomic records in ITIS and/or WoRMS such as feeding type, morphology, or invasive status
- assigning the terms fresh, brackish, or marine to entries in the register
- providing advice in the mapping of species lists to the register to standardize taxonomy, and provide standard codes for mismatches due to variations in spelling of the taxonomic name or missing or misspelled authorship
- providing advice on the mapping of non-taxonomic terms to vocabulary lists
- providing images of taxa for a taxon photo gallery.

### Spreadsheet design

Relational databases with linked tables are commonly employed for data-intensive operations like species registers or checklists. However, spreadsheets (flat files) can be

valuable points of entry or useful intermediate work stages. Several groups, including Barcode of Life (BoL), OBIS, and GBIF, have developed spreadsheet templates and user guides, in particular to assist with field collection or submitting data from new users.

## Database design

The register database is a simple version of the actual database; it contains the taxonomic and related information. In the case of the WoRMS tables, the main fields are as follows:

- AphiaID;
- Taxon name;
- Authority;
- Taxon Rank;
- Taxon status + Record status
- Parent-child relationship (classification);
- Accepted taxon relationship (synonymy);
- Vernaculars (common names);
- Environment flags (marine/brackish/fresh/terrestrial);
- Sources (including weblinks, DOI, PDFs);
- Published distributions (including misidentifications), linked to gazetteer;
- Specimens (including code, museum, links, identification history, and so on);
- Ecological traits (e.g., feeding, associations);
- Deeplinks (e.g., GenBank, BOLD), but also PDFs, file cards, and others;
- Images;
- License;
- Page citation.

The database requirements are a taxonomic table, a list of defined areas (gazetteer), authoritative sources, notes, and flags.

A regional register such as the CaRMS database uses the same technology platform as the WoRMS database. It contains a main (taxonomic) table with names and authoritative notes. Authoritative means that each note is associated with a source and each source is assigned a type (publication, expert, database), and the full reference is also included.



This determination should be conducted by the taxonomic editors rather than the data managers.

The standardized design of the register database will become valuable when checklists are integrated with wider biological databases. This is perhaps especially true for marine species databases that seek to integrate differing groups (plankton, pelagic, benthos, larvae, adults, habitats) and sources (international and national surveys), for example, with initiatives such as LargeNet (Vandepitte et al. 2010).

### **Notes design**

Notes may be of several types—feeding, morphology, habitat—but there are two main types of notes in the WoRMS database. These relate to taxonomy and geographical distribution. The main focus of a regional register is to compile distribution notes for areas of interest to local research.

Notes must be associated with an authoritative source. The source type may be one of the following: expert, database, internet, or publication. Preference is given to recognized published material. Full reference information for all sources used will be included in the literature/source table associated with the species register.

Distribution notes may include a description, but must also contain a reference to a defined area in an associated atlas or gazetteer. The WoRMS database sources the VLIMAR gazetteer.

### **Checklist products**

The checklist may be distributed as a number of products. Publication may take the form of annotated online lists (e.g., Coad 2011, Eschmeyer 2012) or full data papers, as provided by the Pensoft journals (e.g., ZooKeys). Other avenues include website hosting such as the recognized regional species lists on WoRMS (Fig. 7).

The screenshot displays the WoRMS (World Register of Marine Species) website interface. At the top, the WoRMS logo and 'World Register of Marine Species' text are visible. Below the header is a navigation menu with categories like Home, About, Search taxa, Taxon tree, Literature, Distribution, Specimens, Match taxa, Editors, Statistics, Users, Webservice, Photogallery, Info downloads, Glossary, and Log in. The main content area is titled 'WoRMS Regional species lists (RSD)' and features a world map with various colored overlays representing different regional species lists. A legend on the right side of the map lists these registers, each with a corresponding icon and a dropdown arrow:

- Google Satellite #
- RSD
- Arctic Register of Marine Species (ARMS)
- Belgian Register of Marine Species (BeRMS)
- Canadian Register of Marine Species (CaRMS)
- European Register of Marine Species (ERMS)
- Gulf of Mexico Register of Marine Species
- Marine Species Database for Eastern Africa (MASDEA)
- Marine Species of the British Isles an... (MSBIAS)
- New Zealand Register of Marine Species
- North Atlantic Register for Marine Species (NARMS)
- Register of Antarctic Marine Species (RAMS)

At the bottom of the page, a footer states: 'Website and databases developed and hosted by VLIZ - Page generated 2012-03-19 - contact: info@marinespecies.org'.

Figure 7. Registers hosted as regional species lists on the WoRMS website.

## Summary

Marine species checklists share many of the same features and challenges as when compiling checklists of terrestrial and freshwater species. At the same time, there are aspects of the marine environment and data collection that may be important factors when developing a checklist. As a result, defining the scope and obtaining information are often different from land-based biodiversity projects. Because of their different origins and histories, working with marine species registers may emphasize taxonomic standards and spatial definitions with biodiversity-related programs such as WoRMS and OBIS and maritime agencies for mapping. These programs may provide additional or marine-oriented and updated information, complementing the global biological data community and assisting with the maintenance of checklists.

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## Appendix 1. Case Example: BeRMS

The Belgian Register of Marine species is a regional species database within the World Register of Marine Species. It only includes species that are currently or were historically occurring in the Belgian part of the North Sea. All species were taxonomically and geographically validated before being added to the list. The geographic validation includes the verification of its appearance within the defined region by field experts. Taxonomic validation is done by the taxonomic experts connected with the World Register of Marine Species.

Since 2000, the Flanders Marine Institute (VLIZ) has compiled distribution information on species from the Southern Bight of the North Sea into a single database known as the Taxonomic Information System for the Belgian coastal area, TISBE. TISBE tried to develop a comprehensive list of all species recorded for the Belgian coast, the Southern Bight of the North Sea, and its surrounding countries. The focal area for this species list spanned from the rocky shores of the Boullonais in North France to southern Holland, including the Delta area and the Scheldt estuary.

Despite the availability of a general list for the Southern Bight, there was a growing demand for a species list only containing species present in the Belgian part of the North Sea. In 2010, this general request led to the development of BeRMS, the Belgian Register of Marine Species, a regional species database within the World Register of Marine Species (WoRMS).

BeRMS was primarily based on TISBE and extended with data and information from existing initiatives. A number of databases containing Belgian marine distribution data were searched for relevant species observations not yet included in BeRMS, such as the Integrated Marine Environmental Readings and Samples database (IMERS) and the European Ocean Biogeographic Information System (EurOBIS), both developed and maintained by VLIZ. In addition, a new literature search was started to further complete the Belgian marine species list.

This literature search, however, showed that not all distribution records were trustworthy, leading to the fact that—solely based on literature—there would probably be an overestimation of the number of species present in the Belgian part of the North Sea. This conclusion led to an additional quality check, where a whole range of field experts were contacted and asked to help verify the geographical spread of all the species listed as “present in the Belgian part of the North Sea”—based on literature—and to list additional species or specific comments on a species such as “extinct in Belgian marine waters,” “vagrant,” “misidentification”, and so on. All this additional information is also

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stored in the database. All experts contributing to the geographical validation of the species are acknowledged for their work and included in the “VLIZ Belgian Marine Species Consortium,” which is listed on the website.

The Belgian Register of Marine Species is regularly updated: marine biologists are still intensively studying the Belgian part of the North Sea and observations of currently undetected species are bound to happen. Some groups, such as bacteria and protozoa, are poorly studied within Belgium, making it currently impossible to create a trustworthy species list for these groups. Research within Belgium is conscientiously followed up and any new observations will be added to the register.

As BeRMS is part of the World Register of Marine Species (WoRMS), the taxonomic correctness of the included species names is guaranteed by the taxonomic experts who manage and maintain the content of the World Register.

VLIZ Belgian Marine Species Consortium. 2010. The Belgian Register of Marine Species. Online available at <http://www.marinespecies.org/berms>. Consulted on 2012-03-29.

## Appendix 2. Case Example: CaRMS

The Canadian Register of Marine Species (CaRMS) is a register containing authoritative distribution records of interest to Canadian researchers, principally from Canadian regions, but also in areas of interest that may fall outside of Canadian waters.

CaRMS grew from local registers of marine species, such as the Northwest Atlantic Register of Marine Species (NWARMS) and the Gulf of Maine Register of Marine Species (GoMRMS), both of which were compiled by the Atlantic Reference Centre of the Huntsman Marine Science Centre, St. Andrews, New Brunswick. The scope of CaRMS is to contain detailed distribution records for taxa found in the three oceans surrounding Canada: the Atlantic, the Arctic, and the Pacific.

CaRMS is recognized by WoRMS as a regional species list. The intent of CaRMS is not to duplicate WoRMS, and CaRMS was not designed to track changes in taxonomy. Each record in the register contains a standard code that enables linkage to master databases such as the WoRMS (AphiaID) and the Integrated Taxonomic Information System (ITIS TSN). Issues related to synonymy, validity, and taxonomic hierarchy will be dealt with by these organizations.

Distribution records for names listed in CaRMS have been or are being verified by local taxonomic experts. The CaRMS editorial board does not directly have the authority to modify taxonomic information stored in WoRMS or ITIS; however, the editors may collaborate with the WoRMS/ITIS taxonomic editors to effect changes.

Additional features of CaRMS include a web photo gallery of contributed images from Canadian specimens and a checklist webpage for several marine subregions in Canada.

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