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Enhanced seamount location database for the western and central Pacific Ocean: screening and cross-checking of 20 existing datasets

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Enhanced seamount location database for the western and central Pacific Ocean: screening and cross-checking of 20 existing datasets.

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Abstract

Seamounts are habitats of considerable interest in terms of conservation and biodiversity, and in terms of fisheries for bentho-pelagic and pelagic species. Twenty datasets on seamounts and bathymetry from different sources and scales (from individual cruise to worldwide satellite data) have been gathered to compile a detailed list of seamount features for the Western and Central Pacific Ocean. None of the datasets is complete and errors exist in most of them. The Kitchingman and Lai (2004) dataset (KL04) from satellite altimetry data provided the baseline of this study because it covered the entire region of interest and includes depth information. All KL04 potential seamounts were cross-checked with other datasets to remove any atolls and islands incorrectly classified as seamounts, to add seamounts previously undetected by KL04, to update the overall database (geolocation, depth) and provide a 12-classes typology of the different types of underwater features. Of the 4,132 KL04 potential seamounts identified, 835 (20%) were actually atolls and islands and 268 were multiple identifications of the same feature (e.g. multiple peak seamounts) and 2 were removed, leaving 3,027 actual underwater features. Conversely, 541 seamounts documented in other datasets but not registered in KL04 were added. The screening of all the potential WCPO seamounts produces a list of 3,568 features with accurate position and information that should have many applications in fisheries and oceanography.

Introduction

Seamounts are major geomorphological features of the ocean floor. They raise a lot of interest from both geological and biological point of view. Geologically, seamounts' abundance and distribution provide information on seafloor formation (Batiza, 1982; Smith & Jordan, 1988; Hillier & Watts, 2007). Biologically, they are considered as biodiversity hotspots with high levels of endemism (Richer de Forges *et al.*, 2000; Worm *et al.*, 2003; Morato, 2003). They also aggregate commercially valuable fish such as orange roughy or tuna. Accurate list of seamounts characterized by their position and summit depth is invaluable for fishery management (Rogers, 1994; Fonteneau, 1991). By providing both commercial resources and unique biodiversity, they are of particular interest for conservation and ideal candidates for offshore and high-seas marine protected areas (Roberts, 2002; Harris, 2007). In this context, accurate inventory of seamounts is necessary at both regional and country levels.

Several studies have been recently conducted to locate and quantify the extent of these unique features at the global scale (Hillier & Watts, 2007; Kitchingman & Lai, 2004; Wessel, 2001). These broad scale works are relying on automatic detection of potential seamounts by the analysis of global bathymetric maps obtained by a combination of satellite and ship-tracks data. The number of detected seamounts varies widely between the different data sets. A primary source of variability lays in the definition of a seamount, its mathematical transcription (algorithm) as well as on the quality of the baseline bathymetric maps. Moreover, since ground-truthing has been limited, seamount databases remain to date largely invalidated. This situation will continue to cast some doubts on fishery management decisions and conservation strategies till uncertainties in the different data sets have been clarified.

As a first step towards a better database of seamount location and morphometric characteristics, the current lists of seamounts needed to be compiled, screened and cross-checked. We report here on the conclusions of this exercise for a number of EEZ and high-seas areas of the Western and Central Pacific Ocean (WCPO). Our interest is in fishery applications so, we paid particular attention to shallow features (<1000m). The potential seamounts identified by Kitchingman and Lai (2004) (hereafter referenced as KL04) were used as the base reference since it provided the largest spatial coverage in WCPO, the highest number of features and provided depth information as well. KL04 features were spatially cross-checked with 19 different seamount and bathymetry datasets available from the literature and the web. Specifically, we aimed to remove from KL04 features incorrectly classified as seamounts, to add seamounts previously not detected, update the overall database (geolocation, depth) and finally set a consistent typological frame to thematically and unambiguously classify the potential seamounts into a number of geomorphological types.

Material and Methods

1/ Data sets and typology of underwater features

Twenty seamount datasets, bathymetric charts and emerged and partially emerged feature maps have been collected from the literature and from a variety of official websites. They covered the western and central Pacific Ocean area (45°S – 32°N and 130°E – 120°W). We focused here on a number of EEZ and high-seas areas which are relevant for on-going offshore fishery monitoring programs (Figure 1). Data came from two main sources: satellite-derived bathymetry and/or ship-derived bathymetry. They had variable spatial coverage and resolution and provided different types of information with specific shortcomings and assets (Table 1).

The Kitchingman & Lai (2004) (KL04) dataset was selected for this study as the prime referential against which the other datasets were cross-checked. Indeed, KL04 provided the highest number of features with the best spatial coverage in the WCPO, and gave summit depth data. The later information is crucial for fisheries application.

All datasets, bathymetric charts and maps were imported into a Geographical Information System (GIS) system prior cross-checking.

To work consistently between data sets and properly classify the potential seamounts, a typology of underwater features has been established. Indeed, no standardized global typology was available despite the number of admitted definitions of underwater features (International Hydrographic Organization & Intergovernmental Oceanographic Commission, 2001).

For shallow features, the Millennium Coral Reef Mapping Project (MCRMP) global standardized typology based on coral reef geomorphology has been used as the main source of information (Andréfouët *et al.*, 2005). It complemented the Shuttle Radar Topographic Mission Water Bodies Database (SWBD) that provided land emerged areas. Indeed, MCMRP exhaustively provided shallow intertidal coral reef flats along banks, atoll and islands which were not visible on the radar imagery used by SWBD. MCRMP products come from 30 meter spatial resolution satellite imagery (Landsat).

For deep features, the typology was based on the information provided by the other datasets. However, the different nomenclatures did not always properly capture the actual geomorphology of the named feature. The most frequent nomenclature was retained if the same feature was named differently by different datasets (e.g. Capricorn seamount, Capricorn guyot, Gora Kaprikorn, Capricorn tablemount). In the specific case of the New Zealand seamount dataset, underwater features were classified into seamount, knoll and hill according to their elevation, so in this case not necessarily following the nomenclature.

In case of complete lack of geomorphological information, the “Unknown” and “Deleted” labels were added to name these non-informed seamounts.

2/ Cross-checking

The shallow features have been mostly compared to the MCRMP and SWBD data sets. An 8-km buffer was considered around each KL04 features. Overlay between KL04, MCRMP and SWBD datasets immediately allow the identification of potential seamounts misidentified for atolls and islands. Both MCRMP and SDBM prove useful in also cross-checking features previously identified as deep features, at hundred of meters below the surface.

Geographically aggregated potential seamounts were carefully plotted on top of bathymetric maps (including multibeam maps for several EEZs and S2004) to confirm if they represented several seamounts or rather a unique large feature. In the case of multiple occurrences capturing the same feature, only the record located on top of the center of the feature was conserved. Redundant records were thus removed from the database.

3/ Updating and completing the database

The position retained to locate the feature is the one matching the center of the feature on the bathymetric map if significant shifts were found between the reported position by the different databases and the summit of the feature.

The summit depth information provided by ship cruises datasets were retained since they were considered as more accurate than altimetry-derived data, particularly in shallow areas. All completely submerged features identified by MCRMP were assigned an average 40m depth value, which corresponds to the maximum depth of penetration on Landsat satellite images acquired over clear oceanic waters. When several datasets provided different depth for the same feature, the most frequently cited and realistic was recorded. Finally, when no other information was available, the KL04 depth data was kept unchanged.

The name of the feature was included in the database when it was mentioned in one of the datasets.

Seamounts not listed in KL04 but inventoried in another dataset were added to the database after screening and cross-checking with bathymetric maps and other datasets. For instance, the Wessel, (2001) dataset indicated many non-informed seamounts that were not identified by any other datasets. Thus, they were not added to the final database. A major source of addition is the New Zealand seamounts database. It included numerous low-elevation underwater features (less than 1000 m) that were described as knolls and hills. Other important sources of addition are NGA Underwater features, Seamount Catalogue and GEBCO.

RESULTS

1/ Results of the screening of the KL04 dataset

Overlays between data sets and visual checking allowed identifying four major problems in KL04 dataset (Figure 2):

i) many shallow and low emerged features such as atolls and islands were misidentified as potential seamounts (type 1-error),
ii) unique large features were indicated by several potential seamounts (type 2-error),
iii) most of the potential seamounts are incorrectly positioned (type 3-error),
iv) summit depths were not accurate, especially for shallow features (type 4-error).

From the 14,287 potential seamounts identified by Kitchingman & Lai, (2004) at the global level, 8,952 were located in the Pacific. In our region of interest (Figure 1) 4,132 KL04 potential seamounts have been screened.

Two potential seamounts have been deleted from the database as they were not visible on the bathymetric map and not mentioned by any other dataset.

835 of KL04 potential seamounts (20.2%) were actually emerged or partially emerged features (island, atoll, and bank – type 1-error).

731 potential seamounts were duplicates (type 2-errors). This type of error is more common for emerged features (463 duplicates) than for underwater features (268 duplicates).

Type 4-error on depth estimation varied from 1 to 1727 m for emerged features (depth of 0 m) misidentified for potential seamounts in KL04. The error was from 1 to 10m depth for 82% of the emerged features, from 10 to 500 m for 16.7% and more than 500m for 1.2% of the emerged features.

2/ The validated final database

2.1/ Number of features, list, example

Finally, a total of 3,568 unique underwater features have been validated in our area of interest (3,027 KL04 and 541 from other databases). An example of the results of the screening and cross-checking is provided for Tonga waters (Figure 3). The complete list of validated seamounts and their attributes is available from the authors.

2.2/ Typology

The compilation of the existing terminology used in the various datasets provided a 12-classes geomorphologic typology of features (Table 2).

603 features (16.9%) were labeled as seamounts, 618 (17.3%) were assigned a different geomorphological label and 2347 (66%) were left unlabelled.

2.3/ Applications of the database

2.3.1/ Conservation: distribution of the features according to the jurisdictions (EEZ *vs.* High Seas)

3,392 of the unique underwater features are located in the EEZs of the studied area with 2,121 in the Pacific Island Countries and Territories EEZs (i.e. excluding New Zealand, Australia, Indonesia, Japan, Hawaii) (Table 3).

176 potential seamounts have been validated in the adjacent high seas covered by this study (Figure 1); however 2,011 potential seamounts that have been identified by KL04 in the surrounding high seas have not been screened mainly because of the absence of complementary data for cross-check and of the time required to complete this cross-checking.

2.3.2/ Fisheries: distributions of the seamounts according to their summit depth

In regards to the relevance of seamounts to pelagic ecology and fisheries, the summit depth appears very important. Shallow and intermediate seamounts, respectively which summit reaches the euphotic zone and the limit of the deep scattering layer (DSL), may be characterized by specific oceanographic features that will have a potential impact on the pelagic ecosystem and fisheries exploiting it. Potential seamounts which depth is located between the surface and 1000m depth represent 19.2 % (674) of the studied seamounts. The mode of the frequency distribution of summit depth is located in the 1500-2000m depth range (Figure 4).

DISCUSSION/ CONCLUSION

Compiling the different datasets available into a unique list of underwater features of which redundancy and false positives were removed allowed clarifying the numbers of seamounts, their depth, position and some other characteristics in the WCPO.

This exercise also highlighted 2 major limitations that introduce uncertainties in the results of some of the datasets screened during this study.

The main limitation to infer the position, depth and number of potential seamounts is the resolution of the bathymetry grid used. In our study it is particularly obvious for the KL04 dataset which constitutes the basis of our work. Four types of problems have been detected in the KL04 dataset: misidentification of emerged features, multiple detections for a unique feature, wrong position and inaccurate summit depth. These errors are associated to the use of ETOPO2 (US National Geophysical Data Center, 2001 - http://www.ngdc.noaa.gov/mgg/fliers/01mgg04.html) as the background bathymetry grid. For our area of interest ETOPO2 is based on the Smith & Sandwell (1997) 2-min Mercator-projected bathymetry grid derived from satellite gravity data combined with ship measurements. In their review of global bathymetry grids, Marks & Smith (2006) evaluated the weaknesses of ETOPO2: low resolution (2 minutes = 13.7 km^2 at the equator), misregistration in latitude and longitude inducing a 2-8 km horizontal

systematic offset to the northeast, smoothing effect resulting in a blurring of some features such as seamount summits and poor bathymetry prediction in shallow waters.
Comparison of satellite-derived bathymetry with seabeam data allowed quantifying the error on summit depth or seamount height. Errors by as much as +- 25% of the actual value was estimated by Wessel & Lyons (1997) and errors of 13-15% were calculated by Baudry (1991). Part of the error is attributed to a poor correlation between bathymetry prediction and altimetry data (Marks & Smith, 2006). However, Etnoyer (2005) consider that for bathymetry grids based on Smith & Sandwell (1997) 50 to 90% of the depth discrepancy can be explained by large cell size, that is low resolution.
Actual resolution of the global bathymetry grids only allows detecting large seamounts. In their study Kitchingman & Lai (2004) used a 1000m-height criteria to define and detect the seamounts while Wessel & Lyons' (1997) choices in seamount-defining criteria limited their technique to finding seamounts larger than ~1500m in relief. On the other hand a recent analysis of ship-track bathymetry allowed Hillier & Watts (2007) to detect seamounts which height varied from 100 to 6700m, accessing then all the smaller underwater features such as hills and knolls. This later study shows that precise data are required to allow an accurate detection of smaller features such as pinnacles (narrow steep seamounts) or small seamounts. Moreover better-resolution data would improve the detection of deep features; indeed the accuracy of detection of seamounts on altimetry data decreases when the depth of the water increases (Smith & Sandwell, 2004).
Marks & Smith (2006) and Sandwell *et al.* (2006) recently argued in favor of the implementation of a new bathymetry-from-space mission to obtain higher resolution data. It would allow detecting numerous features including small seamounts that at the moment fall below the resolution of existing data. Marks & Smith (2006) also suggest the incorporation of more recent ship-data and higher-resolution regional and local surveys to improve the bathymetry grid.

Another important limitation to the proper classification of underwater features into seamounts is the absence of undersea feature names standardization. In our study we had to implement a classification of the features to properly separate seamounts from other undersea features. We also realized that a large number of features were not described and consequently could not be classified in our typology. Indeed very few seamounts have been properly explored: it is estimated that from the 100,000 potential seamounts worldwide, only 350 have been sampled and less than 100 in any detail (censeam.niwa.co.nz). Albeit definitions of underwater features have been standardized (International Hydrographic Organization & Intergovernmental Oceanographic Commission, 2001), the nomenclature found on the charts and in the datasets does not always match the geomorphology of the feature. The quality of the topography used to identify and name the features is of course primordial for a proper description and denomination. A large international project for the proper classification of worldwide undersea features should be developed as it was done for the coral reef structures worldwide under the Millenium Coral Reef Mapping Project. Such study would require the acquisition of detailed bathymetric maps to be able to distinguish the geomorphology of the feature. These detailed data would then need to be screened by a unique team to make sure that the same standardized criteria are used to consistently classify the different structures observed.

There are many potential applications for an accurate list of seamounts with information such as positions and summit depths, e.g. study of the oceanic crust formation and evolution, study of the benthic biodiversity and biogeography of the fauna, marine protected areas. More specifically the list of seamounts produced in this study will be used to explore the impact of the seamounts on the pelagic fisheries in the western and Central Pacific Ocean. The positions and depths of the seamounts and other underwater features will be cross-checked with tuna fisheries data in the region to try and identify the impact of the seamounts on tuna production and consequently on the fisheries.

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FIGURES

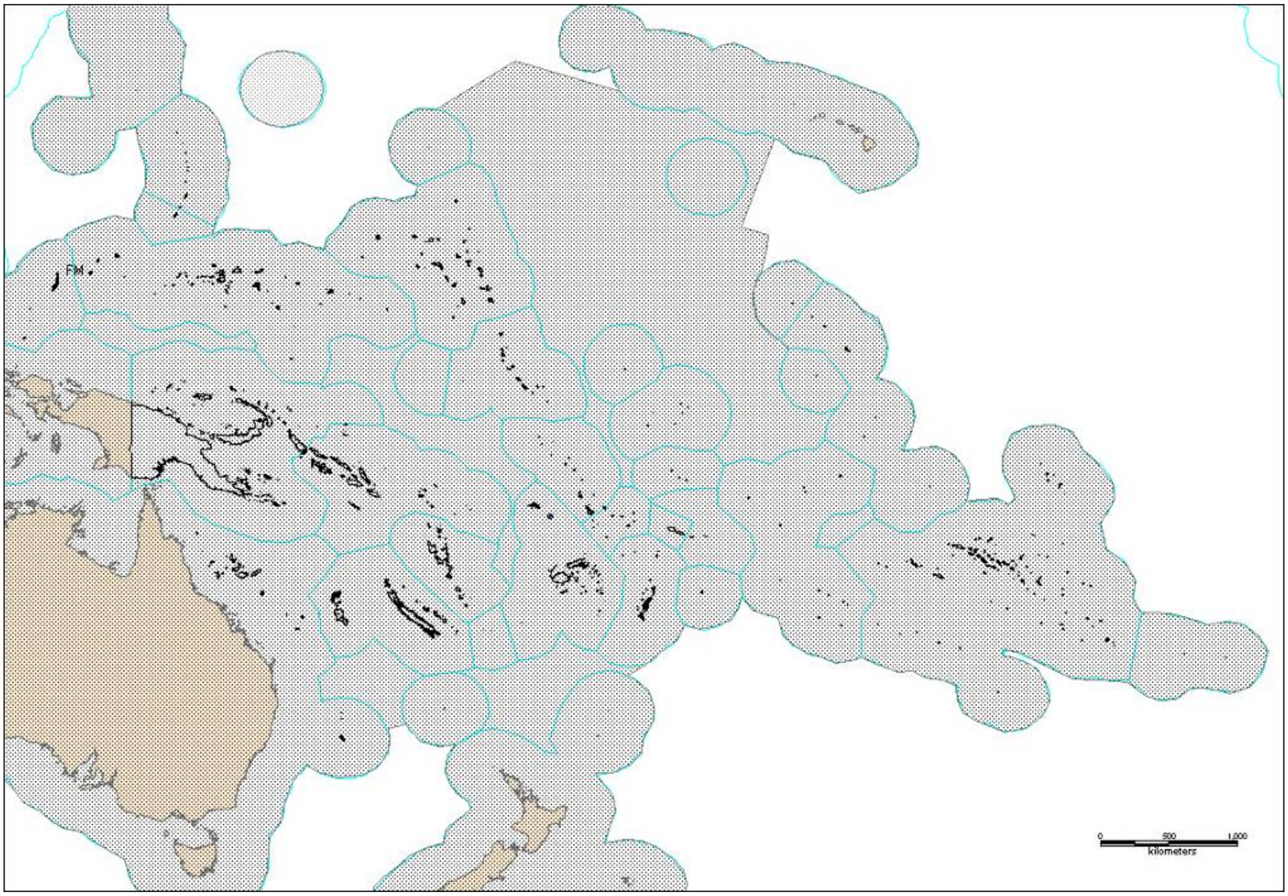

Figure 1. Area of interest. Bounded by the 45S-32N / 130E-120W domain. It includes Exclusive Economical Zones of most Pacific Ocean countries, and several high-seas international areas.

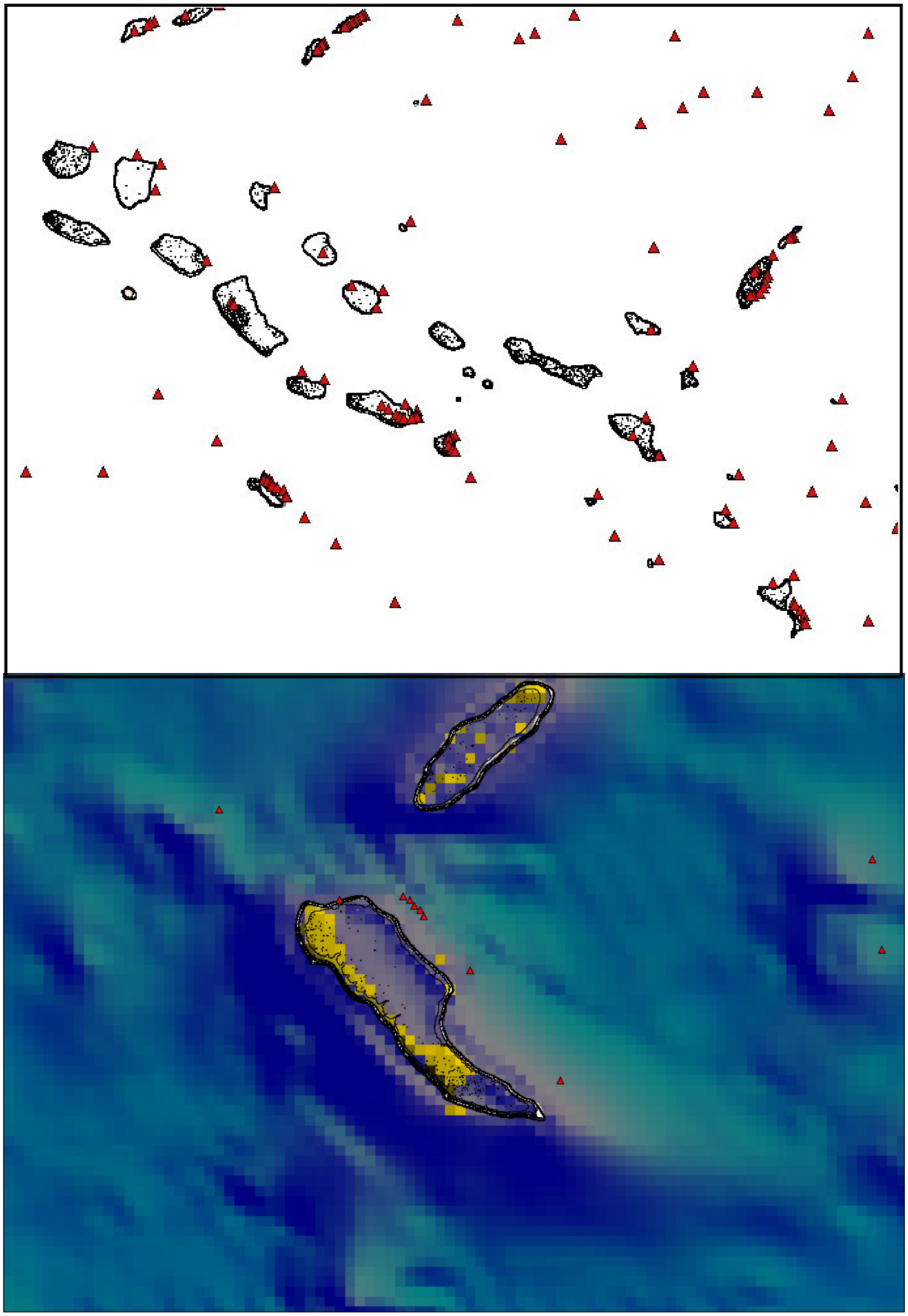

Figure 2. Illustrations of identified problems in the Kitchingam and Lai (2004) dataset. Top panel : regional view of the patterns in Tuamotu Archipelago (French Polynesia) highlighting confusions between KL04 seamounts (triangles) and atolls mapped by MCMRP and SWDP datasets (black outlines show the rim of the atolls).This example also illustrates how large unique features, here atolls, are represented by several seamounts. Bottom panel: enlargement and illustration of the same issues around Hao atoll in Tuamotu Archipelago.

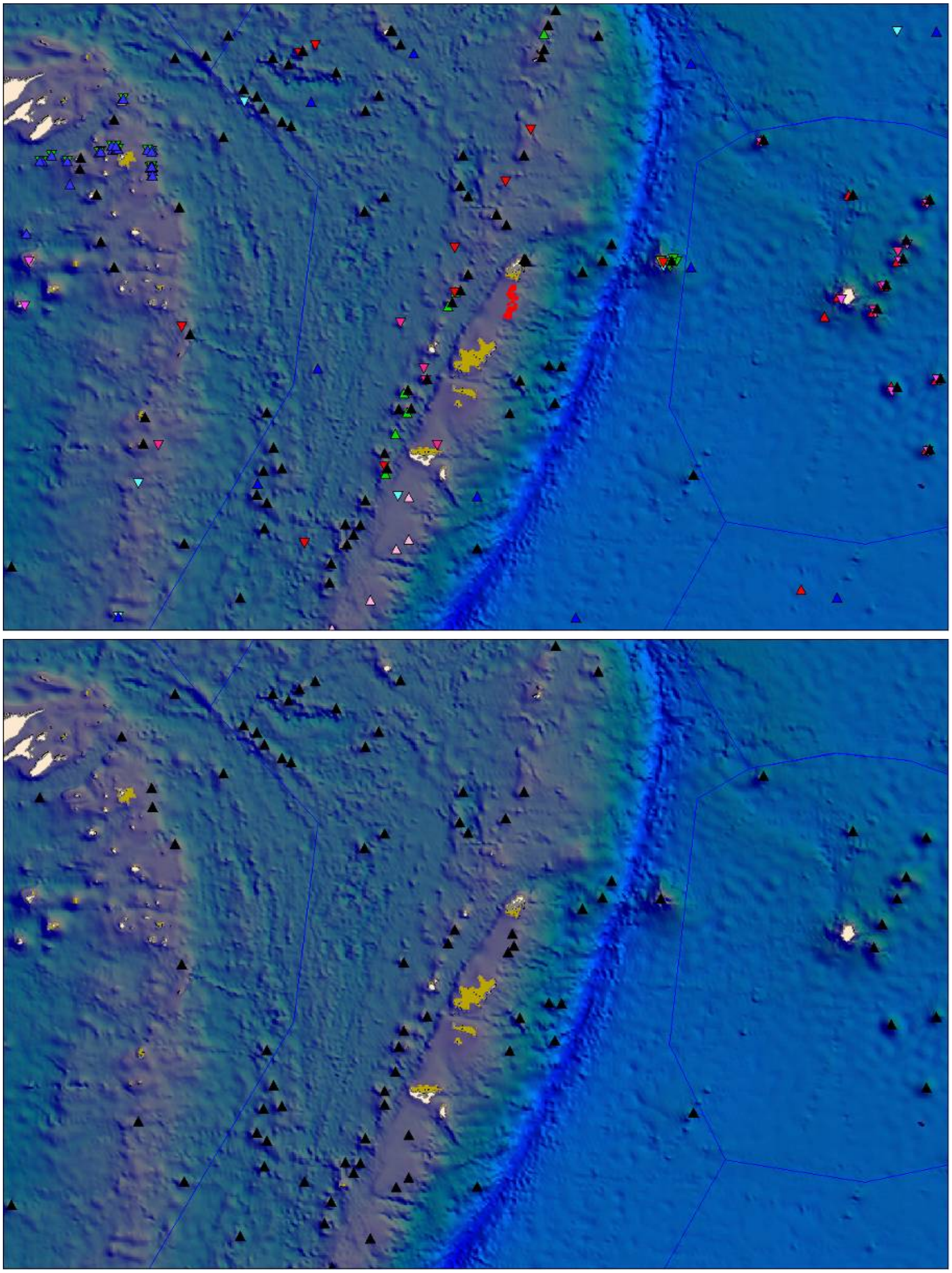

Figure 3. Example of the seamount databases before and after cross-checking for the Tonga area. Top panel: all datasets are presented, using different colors. Bottom panel: only the final validated underwater features are shown. Duplicates and false-positives have been removed.

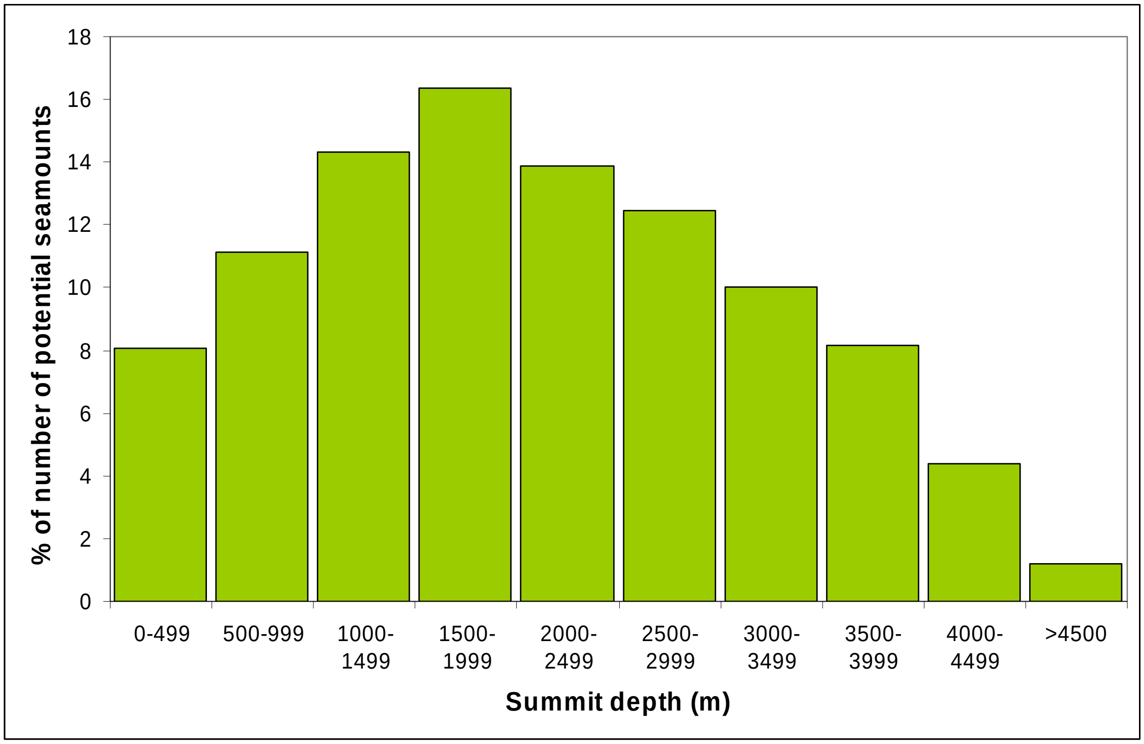

Figure 4. Histograms of summit depth distribution of the validated underwater features for the area of interest shown in Figure 1.

Tables

Table 1. List of the 20 datasets collected for the screening and cross-checking of the seamount database in the WCPO. Three types of data were gathered: bathymetric maps, emerged features maps, seamount lists.

Dataset	Origin	Resolution	Product used and description	Spatial coverage	Flaws	Source or provider
Bathymetric chart						
S2004	1-2	1'	Bathymetry grid combining Smith & Sandwell (1997) grid for areas deeper than 1000m depth (satellite altimetry data) and GEBCO grids for areas shallower than 200m depth (ship sonar data and soundings); smooth blend between 200 and 1000m depth	Worlwide	Poor bathymetric prediction in shallow waters GEBCO information is limited by chart accuracy	Smith (unpublished); Marks & Smith (2006) ftp://falcon.grdl.noaa.gov/pub/walter/Gebco_SandS_blend.bi2
New Caledonia MNT bathymetry	2	500m	Bathymetry grid assembled from single-beam and multibeam data	New Caledonia	Limited spatial coverage	Government of New Caledonia - Zoneco programme http://www.georep.nc/downloadspub.htm
Australia ETBF bathymetry	1	2'	Bathymetry grid Provided by CSIRO derived from US National Geophysical Data Center bathymetric grid - AGSO bathymetry	South East Australia	Limited spatial coverage Low resolution	CSIRO - Jock Young
French Polynesia bathymetry	1-2	1'	Bathymetry grid combining satellite and multibeam data	French Polynesia	Limited spatial coverage	Government of French Polynesia - ZEPOLYF programme -Alain Bonneville
Tonga bathymetry	2	500m	Bathymetry grid issued of scientific cruises multibeam swath bathymetry	Tonga / partial	Limited spatial coverage Partial coverage of the EEZ	Wright et al. (2000) http://dusk2.geo.orst.edu/tonga/
Emerged and partially emerged features maps						
Millenium Coral Reef Mapping project	1	30m	Delineation of shallow underwater features and emerged land in relation to coral reefs detected by Landsat satellite images	Worlwide / partial	Detect features shallower than 40m depth in coral reef areas Partial coverage of the Pacific at the time of the study	Millenium Coral Reef Mapping Project http://imars.marine.usf.edu/corals/index.html Andrefouet et al. (2005)
SRTM Water Body Data (=SWBD)	1	90m	Emerged land delineation extracted from Shuttle Radar Topographic Mission Water Bodies Database	Worlwide / partial	Gaps in the spatial coverage	NASA/NGA - Shuttle Radar Topographic Mission Water Bodies Database. Version 2.0 ftp://e0srp01u.ecs.nasa.gov/
Seamount / underwater features datasets						
Kitchingman & Lai (2004)	1		List of seamount positions and summit depth extracted from ETOPO2 bathymetric chart; seamounts are defined by a rise of 1,000 m or more from the seabed and should be roughly circular and elliptical in shape	Worlwide	Flaws of ETOPO2 Misregistered in latitude and longitude inducing a 2-8 km horizontal shift towardsoffset to the northeast Smoothing effect due to interpolation Poor bathymetric prediction in shallow waters Low resolution	Kitchingman & Lai (2004) http://www.seaaroundus.org/report/seamounts/05_AKitchingman_Slai/AK_SL_TEXT.pdf
NGA - underwater features (13 February 2006)			List of undersea features positions, names and types	Worlwide / partial	No depth information Poor accuracy in positionning of some features	US National Geospatial Intelligence Agency (NGA) - GEOnet Names Server (GNS) http://earth-info.nga.mil/gns/html/index.html
Seamount Catalog (12 April 2006)	2		List of positions, names, summit depths, types and other information of seamounts explored during scientifc cruises	Worlwide / partial	Emerged features such as islands included in the database	Seamount Catalog - Seamount Biogeosciences Network http://earthref.org/SBN/

Table 1. Continued

Dataset	Origin	Resolution	Product used and description	Spatial coverage	Flaws	Source or provider
Seamount / underwater features datasets						
Seamount Online (6 Jan 2006)	2		List of positions, names and types of seamounts explored during scientifc cruises	Worlwide / partial	Small number of seamounts	SeamountOnline - Stocks (2005) http://seamounts.sdsc.edu/
Volcano NGDC (20 February 2006)			List of submarine volcanoes positions and names	Worlwide	Lack of accuracy in positioning of some features	Smithsonian Institution - Global Volcanism Program http://www.volcano.si.edu/world/globallists.cfm
MUSORSTOM cruises (14 February 2006)	2		List of positions, depths and names of seamounts explored during the MUSORSTOM scientific cruises	South west Pacific / partial	Small number of seamounts Depth and positions of sampling not of summit	IRD - Bertrand Richer de Forges http://www.mnhn.fr/musorstom/
New Zealand seamounts (27 April 2006)	2		List of positions, names, depths and elevations of seamount and smaller underwater features explored or detected by single-beam and multibeam echosounding	New Zealand	Limited spatial coverage	NIWA - Malcolm Clarck Rowden et al. (2005)
Australia ETBF seamounts (11 May 2006)	2		List of seamount positions and names detected from Australia ETBF bathymetry map	South East Australia	Limited spatial coverage	Campbell & Hobday (2003)
Wessel (2001)	1		List of seamount positions extracted from Sandwell and Smith (1997) altimetry data; seamounts are detected by locating circular maxima in the gridded vertical gravity gradient	Worlwide / partial	Partial coverage of the south west Pacific No depth data Numerous features only located by this	Wessel (2001)
POREMA cruises (2004)	2		List of positions, names and summit depth of seamounts explored during the POREMA scientific cruises	French Polynesia / partial	Small number of seamounts	Government of French Polynesia - ZEPOLYF programme Ponsonnet (2004)
Marshall Island seamounts (1999)	2		List of positions and summit depth of seamounts explored during geological cruises	Marshall Islands / partial	Small number of seamounts	SOPAC - Kojima (1999)
SPC tagging cruises (April 2006)	2		List of positions and names of seamounts explored during tuna tagging cruises between 1990 and 2004	Western and Central Pacific / partial	Small number of seamounts Approximate position	SPC - OFP
GEBCO (31 July 2006)	2		List of positions, names and types of undersea features	Worlwide / partial	No depth data Poor accuracy for the positioning of some features	IHO-IOC GEBCO SCUFN - March 2006 Gazetteer http://www.ngdc.noaa.gov/mgg/gebco/underseafeatures.html

Table 2. Feature typology. The definitions are based on MCRM classification for shallow features and on IHO-IOC (2001) / GEBCO terminology for deep features. Number of features represents the number of unique underwater features in the validated database.

Deep features – Available nomenclature		**Number of features**
Seamount	Underwater mountain rising more than 1000m from the ocean floor and having a peaked or flat topped summit below the surface of the sea.	603
Hill	Elevation rising generally less than 500 meters.	210
Knoll	Elevation rising generally more than 500 meters and less than 1000 meters and of limited extent across the summit.	166
Guyot	Flat – topped submarine mountain.	76
Deep Bank	Large elevated area of the sea floor which is relatively deep.	26
Ridge	Long narrow elevation with steep sides.	61
Plateau	Flat-topped feature of considerable extent, dropping off abruptly on one or more sides.	2
Shallow features – Millennium typology		
Drowned bank	Large and shallow elevated area of the sea floor.	47
Bank	Large and shallow elevated area of the sea floor, which can have an emerged part.	38
Drowned atoll	Ring like coral island and reef that nearly or entirely encloses a lagoon.	30
atoll	Ring like coral island and reef that nearly or entirely encloses a lagoon and which can be partially or totally emerged.	203
Island	Small land mass, entirely surrounded by water.	152
Others		
Unknown	No information is available on the feature but it is identified by an elevation on the bathymetric maps	2347
Deleted	No information is available on the feature and no elevation is visible on the bathymetric maps	2

Table 3. Number of validated underwater features in the high seas and EEZ of the WCPO. PICT: Pacific Island Countries and Territories.

Number of unique underwater features

High Seas - not validated	2011	Total EEZ	3392
High Seas - validated	176	PICTs EEZ	2121

EEZ	Number		EEZ	Number
New Zealand	483		E Australia	76
French Polynesia	338		Tonga	75
S Japan	259		New Caledonia	69
Kiribati	249		Tuvalu	59
FSM	232		Guam	45
Hawaii	217		Am Samoa	34
USA Territories	204		Pitcairn	34
Solomon Islands	158		Tokelau	32
Marshall Islands	151		Vanuatu	27
N Mariana	143		Wallis Futuna	27
Fiji	112		E Indonesia	26
Palau	110		Niue	15
Cook Isl	107		Samoa	15
PNG	89		Nauru	6