Digital Elevation Model of the Society Islands, French Polynesia: Procedures, Data Sources, and Analysis

Prepared for NOAA's Pacific Marine Environmental Laboratory and the National Weather Service by the NOAA's National Centers for Environmental Information (NCEI)
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Summary

In November of 2016, NOAA's National Centers for Environmental Information (NCEI) developed three integrated bathymetric–topographic digital elevation models (DEMs) of the Society Islands for NOAA's National Weather Service (NWS) and Pacific Marine Environmental Laboratory (PMEL). The DEMs will be used to support modeling tsunami generation, propagation, and inundation. The two 1 arc-second DEMs cover both the Leeward and the Windward Islands groups. The three arc-second DEM covers both groups including Maupiti, Tupai, Bora Bora, Raiatea, Tahaa, Hauahine, Maiao, Moorea, Tetiaroa, Tahiti, and Mahetia Islands. Extents of this DEM, procedures, data sources, and analysis are described below. The methodologies used by NCEI in developing DEM are described in the NOAA Technical Memorandum-52 for Central California and San Francisco Bay (Carignan et al., 2011).

DEM Specifications

The Society Islands DEMs were built to the specifications listed in Table 1. Figure 1 shows the 1 arc-second Society Islands integrated topographic–bathymetric DEM boundaries in green and the 3 arc-second DEM in red.

Table 1. Specifications for the Society Islands, French Polynesia DEM.

Cell Size	1 arc-second Leeward Islands	1 arc-second Windward Islands	3 arc-second
Coverage	150.75° to 151.95° W, 17.10°S to 16.35° S	148.85° to 150.10° W, 18.05°S to 17.20° S	147.50° to 153.00° W, 19.00°S to 15.60° S
Coordinate System	Geographic decimal degrees	Geographic decimal degrees	Geographic decimal degrees
Horizontal Datum	World Geodetic System 1984 (WGS 84)	World Geodetic System 1984 (WGS 84)	World Geodetic System 1984 (WGS 84)
Vertical Datum	Mean Sea Level	Mean Sea Level	Mean Sea Level
Vertical Units	Meters	Meters	Meters
Grid Format	ASCII raster grid	ASCII raster grid	ASCII raster grid

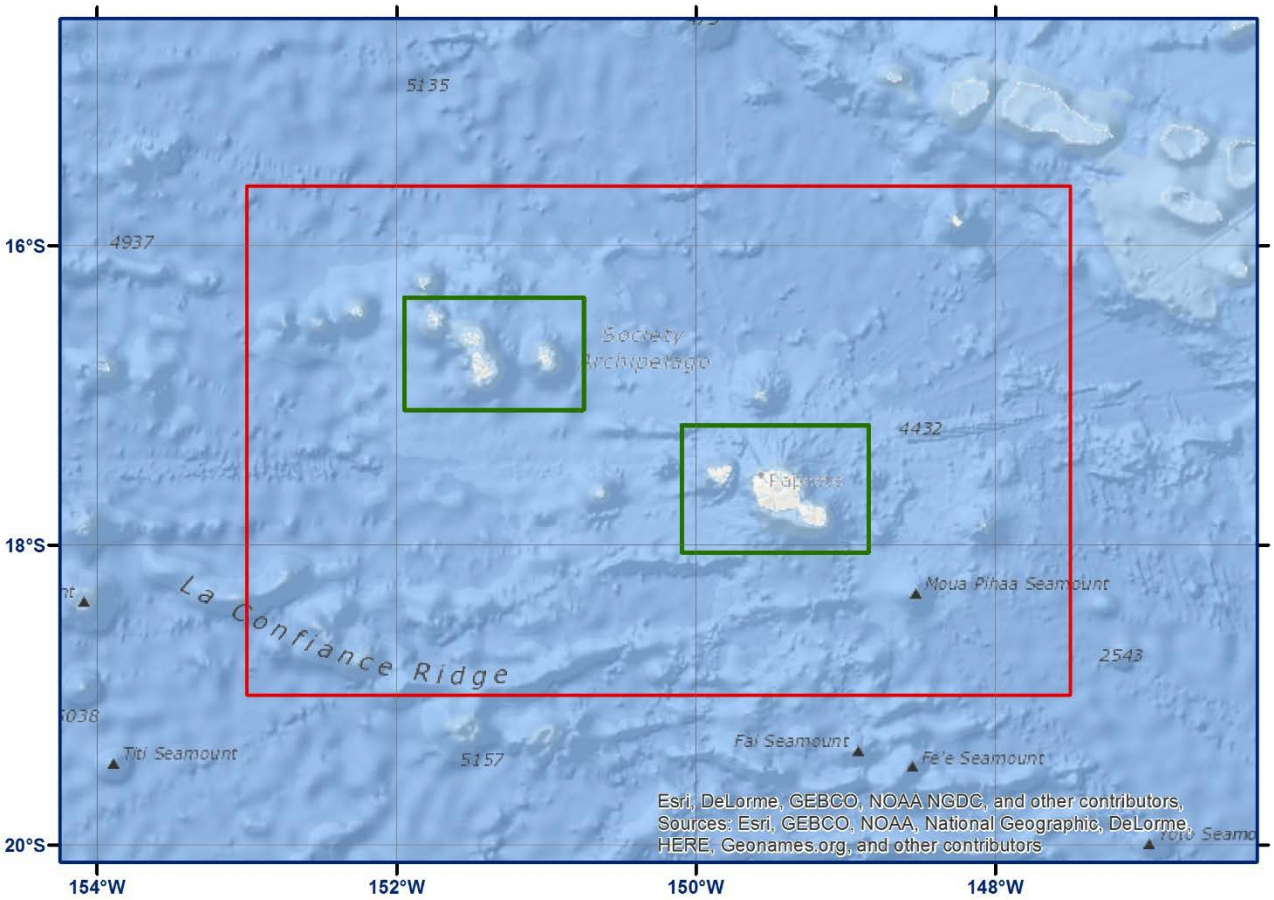

Figure 1. Map image of the boundaries for the 1 arc-second Society Islands DEMs in green and the 3 arc-second DEM in red.

Data Sources and Processing

Digital coastline data were extracted from NGA digital nautical chart data. These data were merged with coastline data from the Millennium Coral Reef Mapping Project and edited as needed to match high resolution lidar data along the coast. The coastline shapefile was used as source data and to develop a clipping mask for the bathymetric surface. Bathymetric data were downloaded from the General Bathymetric Chart of the Oceans (GEBCO), Japan Agency for Marine-Earth Science and Technology (JAMSTEC), SeaDataNet, the Moorea Coral Reef Long Term Ecological Research Network (LTER) and NCEI. Bathymetric data were also provided to NCEI by the Living Oceans Foundation (KSLOF). Bathymetric-topographic lidar data were downloaded from Service hydrographique et océanographique de la marine (SHOM) and SRTM topographic DEMs were downloaded from USGS Earth Explorer and NASA Earthdata. Figure 2 shows the source and coverage of the datasets used in developing the Society Islands DEMs.

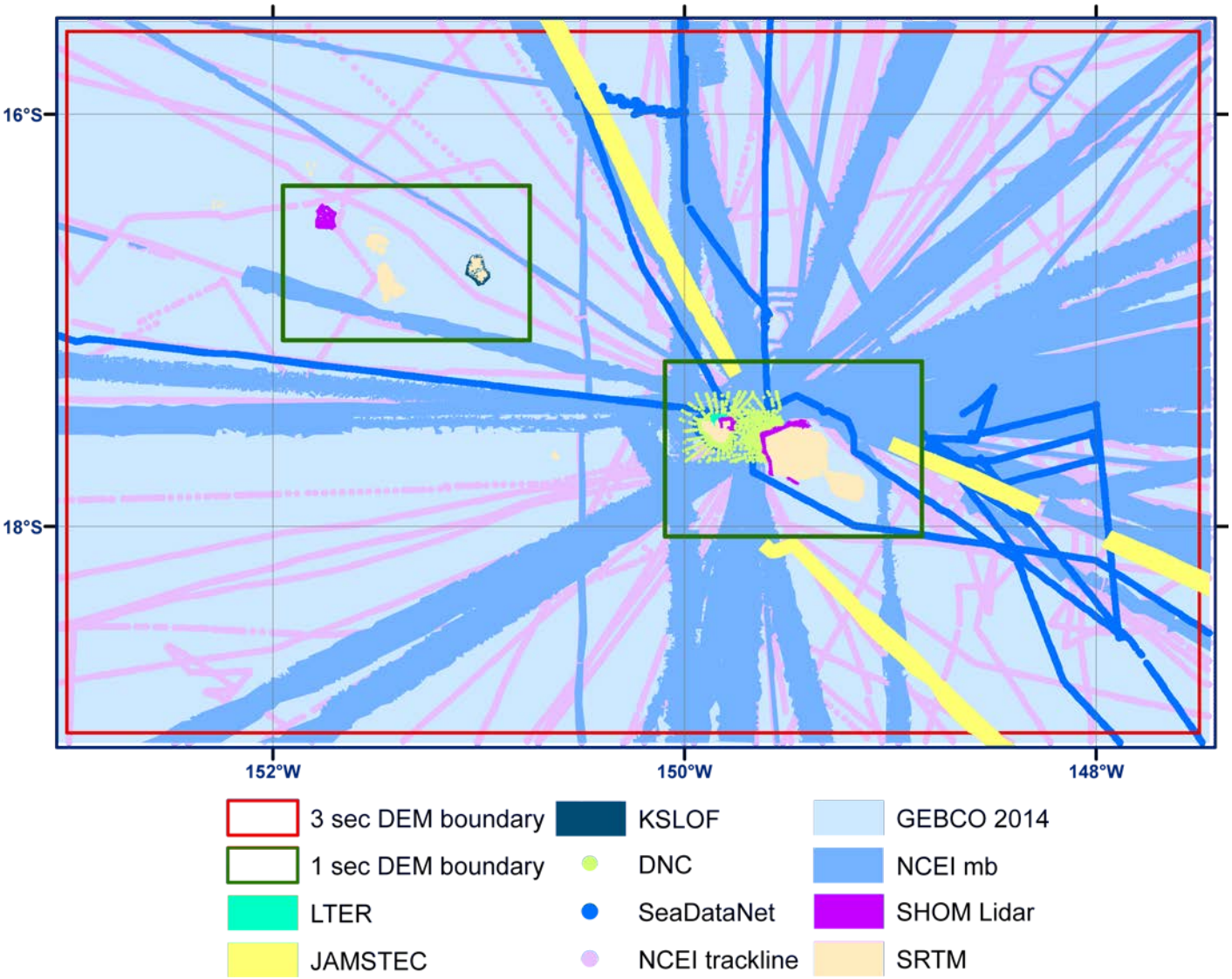

Figure 2. Source and coverage of the datasets used in compiling the Society Islands DEMs.

Table 2 lists the bathymetry data used in the compilation of the Society Islands DEMs including NCEI multibeam surveys (Appendix A), DNC soundings, JAMSTEC multibeam data, LTER gridded survey data, Seadatanet bathymetric surveys, and KSLOF optically derived bathymetry and the GEBCO 2014 gridded bathymetry dataset.

Table 2: Bathymetric data sources used in compiling the Society Islands DEM.

Source	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
NGA DNC	2014 to 2015	Nautical chart sounding point data	~ 2 meters to 20 meters	WGS 84 geographic	Mean Low Water (MLW)
LTER	2012	Gridded bathymetry data	20 meters	WGS 84 UTM Zone 6 South	undefined
JAMSTEC	2004 to 2009	Multibeam bathymetry	~ 20 to 100 meters	WGS 84 geographic	undefined
SEADATANET	1994 to 2004	Single beam bathymetry	~ 20 to 100 meters	WGS 84 geographic	undefined
KSLOF	2014	Optically derived bathymetry	2 meters	WGS 84 Web Mercator	undefined
NCEI	1957 to 2012	Single-beam Trackline Bathymetry	~ 25 meters to > 100 meters	NAD 83 geographic	Assumed MSL
NCEI	1982 to 2014	Multibeam bathymetry	30 meter grid	NAD 83 geographic	Assumed MSL
GEBCO	2014	Bathymetric DEM	30 arc-second	undefined	Assumed MSL

Bathymetric data were transformed to WGS 84 geographic using GDAL as needed and where recent, higher resolution data exists, older data were superseded. Bathymetric returns from the SHOM lidar data were filtered and used in generating the bathymetric pre-surface. These bathymetric data were converted to xyz format before combining with the coastline data to generate a bathymetric pre-surface at 6 arc-seconds. This bathymetric surface grid was further processed by running ArcGIS focal statistics tool on the resulting gridded data. This smoothed surface was used as a single data source and reused with only the higher resolution bathymetry data to create the 3 arc-second pre-surface used in the final gridding process.

The SRTM topographic data and SHOM lidar data (Table 3) were transformed to WGS 84 geographic using GDAL and converted to xyz format. As the 1 arc second SRTM DEM was not completely lacking voids, the 3 second DEM was also downloaded and processed using the same steps. SRTM data were also filtered to remove elevation values exceeding the known topographic limits for each island and clipped to the coastline to remove values over water. NGA DNC land elevations were also used to restrict interpolation across areas with minimal data points.

Table 3: Topographic data source used in compiling the Society Islands DEMs.

Source - Title	*Date*	*Data Type*	*Spatial Resolution*	*Horizontal Datum*	*Vertical Datum*
SHOM	2015	Topographic-bathymetric Lidar	< 1 meter to 5 meters	RGPF UTM 6 South or UTM 5 South	NGPF
SRTM	2000	DEM	1 and 3 arc-second	WGS 84 geographic	EGM96 (Earth Gravitational Model 1996) ellipsoid

DEM Development

Development of the Society Islands DEMs followed procedures documented in NOAA Technical Memorandum NGDC-52 for Central California and San Francisco Bay (Carignan et al., 2011). Exceptions being the bathymetric pre-surface was generated at 3 arc-second. Gridding weight was modified to Table 4.

Table 4: Data hierarchy used to assign gridding weight in MB-System for 3 arc-second DEM.

Dataset	*Relative Gridding Weight*
SHOM	1000
JAMSTEC	100
KSLOF	100
LTER	10
SRTM 1 sec. DEM	10
Bathy pre-surface	1
Coastline	1
DNC land elevations	1
SRTM 3 sec. DEM	1

DEM Analysis

The completed Society Islands DEMs were compared to chart contour data and high resolution imagery. Inconsistencies were evaluated and resolved based on most current or reliable data available.

Acknowledgement

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Appendix A: NCEI Multibeam surveys

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
AMAT01RR	2006	Roger Revelle	UNOLS R2R	NAD 83 geographic	Assumed MSL
AMAT02RR	2006	Roger Revelle	UNOLS R2R	NAD 83 geographic	Assumed MSL
AMAT03RR	2006	Roger Revelle	UNOLS R2R	NAD 83 geographic	Assumed MSL
ARIA01WT	1982	Thomas Washington	University of California, Scripps Institution of Oceanography (UC/SIO)	NAD 83 geographic	Assumed MSL
ARIA02WT	1982	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
BMRG01MV	1995	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
BMRG02MV	1995	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
CNXO01WT	1982	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
COOK03MV	2000	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
COOK04MV	2000	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
COOK15MV	2001	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
COOK16MV	2001	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
COOK17MV	2001	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
CRGN01WT	1987	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
CRGN02WT	1987	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
CRGN03WT	1987	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
EW0003	2000	Maurice Ewing	Marine Geoscience Data System (MGDS)	NAD 83 geographic	Assumed MSL
EW9104	1991	Maurice Ewing	MGDS	NAD 83 geographic	Assumed MSL
EW9204	1992	Maurice Ewing	MGDS	NAD 83 geographic	Assumed MSL
EW9603	1996	Maurice Ewing	MGDS	NAD 83 geographic	Assumed MSL
GLOR04MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
GLOR05MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
KM1416	2014	Kilo Moana	UNOLS 2R	NAD 83 geographic	Assumed MSL
KM1417	2014	Kilo Moana	University of New Hampshire, Center for Coastal and Ocean Mapping (UNH/CCOM)	NAD 83 geographic	Assumed MSL
MV0911	2009	Melville	UNOLS R2R	NAD 83 geographic	Assumed MSL
MV1001	2010	Melville	UNOLS R2R	NAD 83 geographic	Assumed MSL
NBP1403	2014	Nathaniel B. Palmer	MGDS	NAD 83 geographic	Assumed MSL
PANR05MV	1998	Melville	UC/SIO	NAD 83 geographic	Assumed MSL

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
PANR06MV	1998	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
RC2608	1985	Robert D. Conrad	MGDS	NAD 83 geographic	Assumed MSL
RITS93B	1993	Surveyor	NOAA	NAD 83 geographic	Assumed MSL
RITS94A	1993	Surveyor	NOAA	NAD 83 geographic	Assumed MSL
RNDB16WT	1989	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
RR1212	2012	Roger Revelle	UNOLS R2R	NAD 83 geographic	Assumed MSL
RR1213	2012	Roger Revelle	UNOLS R2R	NAD 83 geographic	Assumed MSL
SOJN01MV	1996	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
SOJN02MV	1996	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
SOJN08MV	1997	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
SOJN09MV	1997	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
TN303	2013	Thomas G. Thompson	UNOLS R2R	NAD 83 geographic	Assumed MSL
TN304	2014	Thomas G. Thompson	UNOLS R2R	NAD 83 geographic	Assumed MSL
TUIM03MV	2005	Melville	UNOLS R2R	NAD 83 geographic	Assumed MSL
TUNE01WT	1991	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
TUNE02WT	1991	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
TUNE03WT	1991	Thomas Washington	UC/SIO	NAD 83 geographic	Assumed MSL
WEST01MV	1993	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
WEST04MV	1994	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
WEST05MV	1994	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
WEST12MV	1995	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
WEST13MV	1995	Melville	UC/SIO	NAD 83 geographic	Assumed MSL
ZHNG02RR	2005	Roger Revelle	UC/SIO	NAD 83 geographic	Assumed MSL

Appendix B: JAMSTEC and Seadatanet surveys

Survey ID	*Date*	*Ship*	*Institution*	*Original Horizontal Datum*	*Original Vertical Datum*
YK04-08 Leg 1	2004	Yokosuka	JAMSTEC	WGS 84 geographic	Assumed MSL
MR08-06 Leg 1	2009	Mirai	JAMSTEC	WGS 84 geographic	Assumed MSL
FLUPAC	1994	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);IRD CENTRE DE NOUMEA (520)	WGS 84 geographic	Assumed MSL
OLIPAC	1994	Atalante	COM - Physical and Biogeochemical Oceanography Laboratory (LUMINY) (513);IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486)	WGS 84 geographic	Assumed MSL
FOUNDATION -HOTLINE	1997	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);UNIVERSITE DE BRETAGNE OCCIDENTALE (UBO) /UMR 6538 DU CNRS DOMAINES OCEANIQUES" (1079)"	WGS 84 geographic	Assumed MSL
POLYNAUT	1999	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);Institute of Earth Physics of Paris (519)	WGS 84 geographic	Assumed MSL
PAPNOU99	1999	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);IRD CENTRE DE NOUMEA (520)	WGS 84 geographic	Assumed MSL
BIOSOPE	2004	Atalante	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA (486);LABORATORY OF OCEANOGRAPHY of VILLEFRANCHE (LOV) / OOV (490)	WGS 84 geographic	Assumed MSL