Phase IV Hawaii California Training and Testing EIS/OEIS: Marine Benthic Habitat Database Technical Report

FINAL

Prepared for:

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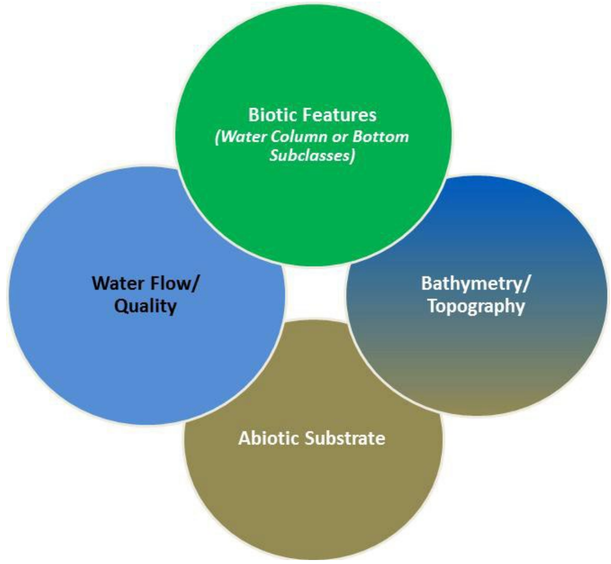
1 INTRODUCTION

Geographic information system (GIS) data sources available within the Hawaii-California Training and Testing (HCTT) Study Area (Study Area) are variable in location, resolution, classification criteria, and accuracy. To ensure that best available data is used in the Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) analyses, the existing database developed for the 2018 HSTT EIS/OEIS was updated to include data fields for habitat feature classes (e.g., primary mapping method, validation methods, spatial resolution), which helped prioritize these data sources. Prioritizing data sources allows higher quality data to be used over lower quality data where they overlap. The resulting refinement of "surveyed" habitat areas better reflect where different bottom types occur, improving the impact analysis within the Phase IV HCTT EIS/OEIS. The HCTT EIS/OEIS habitats resource section (Chapter 3.5) focuses solely on abiotic substrates, with other resource sections focusing on the associated biota (e.g., vegetation, invertebrates). As such, data collection was focused on abiotic substrates to support habitat impact analysis.

The HCTT Marine Benthic Habitat Database was developed to refine and prioritize overlapping habitat data used in the analysis of impacts (e.g., military expended materials and bottom explosions). The database includes numerous data sources that are combined to create a non-overlapping mosaic of habitat information that presents only the highest quality available data for a given location. The database includes primarily polygon features, ant point features for approximate locations of shipwrecks and artificial reefs. The current database is limited to abiotic substrate types assessed in Chapter 3.5 (Habitats) section for the HCTT Phase IV EIS/OEIS. This document provides a detailed description of the database and the ranking scheme used to prioritize data for the analysis in the HCTT EIS/OEIS.

2 CLASSIFICATION SYSTEM

Although this report focuses on abiotic substrate, other themes, or dimensions of aquatic habitat (for which the prioritization scheme may also be applied), provide important context. Figure 1 presents a standard classification scheme for aquatic habitat dimensions that is very similar to the Federal Geographic Data Committee standards. The Federal Geographic Data Committee standard was not exclusively employed because a "Substrate" component can overlap a "Biotic" component (e.g., live hard bottom organisms growing on either rock or limestone substrate) and the dimensions should be inherently non-overlapping (e.g., water flow/quality vs. abiotic substrate) though they can be correlated at any given location (e.g., hard substrate on high relief features of the bottom). Within the abiotic substrate dimension of habitat reported on this document, overlapping data is ranked based on quality. Abiotic substrate forms the surface of bathymetric features (e.g., outcrops, ridges), and may have associated biotic features (e.g., seaweeds, corals, sponges, mussels). Water flow/quality (e.g., water column) has both horizontal (e.g., surface currents) and vertical (e.g., temperature stratification) dimensions with associated biotic features (e.g., floating mats of algae, phytoplankton biomass). Water flow/quality and biotic features associated with various habitats are analyzed in their respective chapter in the HCTT EIS/OEIS (e.g., Sediments and Water Quality, Vegetation, and Invertebrates), and are not included in this report. This report only provides the processing of data sources used to map abiotic substrate types in the Study Area.



Note: The different circles represent the different themes or dimensions of aquatic habitat that can overlap (e.g., water flows over the substrate but surface substrate types should be non-overlapping).
The physical dimensions of habitat include abiotic substrate, bathymetry/topography, and the water column itself. These features, as a resource, are covered in "Sediment and Water Quality" and "Habitat" sections of the Phase IV HCTT EIS/OEIS/

Figure 1: Basic Thematic/Dimensional Aquatic Habitat Classification Scheme

Abiotic substrate is defined as the non-living material forming the topography of a submerged surface. Although many classification schemes are available that span a range of spatial dimensions and granularity (Allee et al., 2000; Cowardin et al., 1979; Federal Geographic Data Committee, 2012; Kendall et al., 2001; Kennedy et al., 1987; United Nations Educational Scientific and Cultural Organization, 2009; Valentine et al., 2005), three types of abiotic substrates are generally based on the grain size of unconsolidated material and degree of consolidation: "soft," "mixed," and "hard" substrates. Soft substrate areas are dominated by mud (including clay and silt) or sand – substrate often too unstable for colonization by habitat-forming sedentary invertebrates (e.g., hard corals, oysters) or attached seaweed, organisms that are the focus of potential impacts for this EIS/OEIS. Hard substrate areas are dominated by rocks or consolidated bedrock that is stable enough for colonization by habitat-forming sedentary invertebrates or attached seaweed. Mixed substrate areas are dominated by unconsolidated material larger than sand but smaller than rocks (e.g., gravel, shells). These areas may or may not be stable enough for habitat-forming sedentary invertebrates or attached seaweeds. Artificial substrate (e.g., shipwrecks, artificial reefs, oil/gas platforms, pipelines) is another type of abiotic substrate that's comprised of man-made material type and origin. Spatial and temporal variation in abiotic substrate is created by the interplay of surficial geology, currents, and water quality at a location.

3 DATA SOURCE QUALITIES

The Action Proponent acquires data mapping of aquatic habitats from various government (federal, state, and local) or private sources including, but not limited to, the National Oceanographic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), Bureau of Ocean Energy Management (BOEM), state resources management agencies, government-funded marine laboratories, and private contractors working on projects with a federal nexus. The data sources are referenced in the section titled Summary of Data Sources. The mapping data sources were compiled and documented in a database. Microsoft Access was used to create a form for documenting the variables needed to rank data quality (refer to section titled Data Quality Ranking Scheme for details). The data table can also be linked to an ArcGIS geodatabase for mapping sources to query for data quality attributes.

3.1 DESCRIPTION OF FIELDS IN DATABASE TABLES

1. Source/Text Citation Table
    a. Source/Text Citation – shows how data sources would be cited in text and links to a "child" table for habitat dimensions/feature classes table
    b. Basic Metadata/Literature Cited – Full bibliographic citation for source
    c. Multi-Dimensional – Check if the source mapped multiple feature classes (e.g., bathymetry/topography, abiotic substrate, and biotic features)
2. Habitat Dimensions/Feature Classes Table
    a. Map_id – unique identifier linking GIS data with Access record
    b. Text Citation – shows how data sources would be cited in text and links to "parent" table for source references
    c. Habitat Dimension/Feature Class (pick only one – a single source can have multiple features classes and geometries)
        i. Bathymetry/Topography – selected if the feature theme(s) depicts depth of the water column or topographic features of the bottom (e.g., outcrops, shelf breaks)
        ii. Abiotic Substrate – selected if the feature theme(s) depicts a substrate classification (e.g., silt, sand, gravel, cobble, boulder/bedrock)
        iii. Biotic Features – selected if the feature theme(s) depicts a biological feature of the water column or bottom (e.g., floating macroalgae mats, seagrass beds, reefs)
    d. Geometry – specify if a feature class is represented by point, line, polygon, or raster geometry
    e. Year Data Collected – the year(s) mapping data were collected (in the field) by the source reference (not necessarily the year of publication); data could be a range (data for every year), multiple non-consecutive years, or a single year
    f. Method (Mapping) – methods that cover largest area of mapping theme
        i. Acoustic Sensor – includes use of devices that detect sound reflectance (e.g., sidescan sonar, single or multi-beam vertical sonar, sub-bottom

profiler)

ii. Bathymetry – reference to bathymetry from navigation charts (typically combined with modeling/interpolation using validation methods)
iii. Benthic Sampler – includes use of devices that extract a sample of the bottom composition, including sedentary or very slow-moving organisms (e.g., benthic grab, sediment core, dredge)
iv. Expert Knowledge – includes use of hand-drawn or digitized boundaries based on expert knowledge
v. Modeling/Interpolation – Typically a combination of bathymetry, expert knowledge and some validation data in the form of points, lines, and/or polygons that do not cover the entire Study Area
vi. Nekton Sampler – includes use of devices that captures non-microscopic mobile organisms in the water column or on the bottom (e.g., trawl, trap). Some organisms can be indicators of persistent aquatic habitat features (e.g., hard bottom).
vii. Other sensor – includes any technology not specifically covered by the specified methods (e.g., magnetometer).
viii. Plankton Sampler – includes use of devices that capture tiny organisms drifting in the water column
ix. Point-based Interpolation – includes polygons interpolated among point samples
x. Visual Observation (direct) – includes direct observation by divers or use of devices that captures video or photographic footage at a resolution similar to direct observation by divers (e.g., underwater video camera, remotely operated vehicle)
xi. Spectral Sensor (remote) – includes use of devices that detect some part of the light spectrum from a remote platform (e.g., aerial photography, satellite multispectral scanner)
xii. Water Flow/Quality Meters – includes use of devices that measure flow velocities or water quality parameters (e.g., temperature, salinity, turbidity, dissolved oxygen)

g. Method (Validation) – methods used to validate classification by the primary method (see mapping methods for listing)
h. Validation Coverage (%) – percentage of the mapping area covered by the validation method
i. Minimum Mapping Unit (m) – smallest area or resolution of the mapped classifications
j. Assemblage Data –selected if the data represents a compilation of different sources
k. Subset Data – selected if the data represents a subset of a series of mapping sources
l. Acquisition Status – the status of acquiring spatial data (e.g. awaiting, received)
m. Data Rank by Theme(s) – a ranking from 0 (lowest quality) to 100 (highest quality) for

the sources mapping a feature theme(s) in the database - see section titled Data Quality Ranking Scheme for more information.

n. Data Preparation/Processing Notes – Documentation for the conversion of data source classification into abiotic substrate types (hard, soft, mixed).

3.2 Description of Fields Included in GIS Geodatabase for Abiotic Substrate Types

1. EcologicalSystem
    - Media ID – abbreviated name of data source
    - Environmental Data IDFK – links to “map_id” field in database (e.g., rank data quality)
    - Feature Name – “abiotic substrate types”
        - Soft – mud (clay or silt), sand
        - Mixed – gravel, cobble; or fine-scale mixture of soft and hard
        - Hard – rock/boulder, bedrock
    - Feature Description – information utilized from source to categorize feature as: soft, mixed or hard
    - Metadata Notes – includes source layer name and study
2. EcologicalSystemP
    - Environmental Data IDFK – links to “map_id” field in database (e.g., rank data quality)
    - Feature Name – name of artificial reef
    - Feature Description – type/composition of artificial reef
    - Metadata Notes – data source and URL
3. TraditionalCulturalResourceP
    - Feature Name – name of Vessel
    - Feature Description – type of wreck
    - Metadata Notes – data source and URL

4 DATA QUALITY RANKING SCHEME

Each source of polygon data was given a rank from 0 (lowest quality) to 100 (highest quality) to determine the highest quality data in a specific location, which was then used for subsequent analysis.

The rank is based on a combination of minimum mapping unit (i.e., mapping resolution), mapping and validation method(s), compatibility of native classification system, and noted adjustments. Qualities of the datasets used to support the qualitative rankings are provided in Appendix B (Data Sources that Support Rank Determinations).

Mapping resolution is straightforward in terms of superiority: smaller minimum mapping units provide a better resolution of data. The minimum mapping units are ranked from 1 (lowest resolution/largest minimum mapping unit) to not greater than the number of datasets (highest resolution/smallest minimum mapping unit) if all the minimum mapping units are different. Data sources with equal minimum mapping units are given the same rank for mapping resolution.

As a comparison of mapping and validation method(s), consider a typical point-based interpolation compared to a highly detailed multibeam sonar, benthic grab, and remote operated vehicle (ROV) survey. When data are available for the same location, the highly detailed survey data (with a higher ranking score) would be used in the non-overlapping mosaic. Although point-based interpolation data could be better than multibeam sonar if the points were close enough together, multibeam sonar data is generally considered to be of higher quality. The mapping and validation methods are ranked from 1 to 4, with 4 being the highest and best methods.

1. Point-based interpolation using benthic sampler validation or bathymetric interpolation and expert knowledge
2. Line-based interpolation (e.g., depth or reflectance profiles) and validation by direct visual observation
3. Bathymetric interpolation/modeling using validation from acoustic sensors, benthic samplers and direct visual observations or acoustic sensor/remote spectral sensor without validation
4. Acoustic sensor or remote spectral sensor using validation from direct visual observation or benthic samplers

Compatibility of native classification system was ranked from 1 (lowest rank) to 3 (highest rank) based on the following descriptions of original bottom type classifications:

1. Bottom classifications are all geologic indicators of abiotic substrate types
2. Bottom classifications can be directly translated into standardized categories or there is a strong correlation of stationary biota (e.g., hard corals, live hard bottom organisms) to a set of factors including hard substrate
3. Bottom classification can be directly translated into standardized categories and there is reference to topography (e.g., high relief hard bottom) and relatively high concentration of stationary biota

The component ranks are combined to yield a total rank from 0–100 using the following equation, assuming 50% is based on resolution, 30% on mapping and validation methods, and 20% on compatibility of native classification system. A bonus or penalty may also be added for additional factors considered for overlapping data.

$$\mathbf{DR = (R/RH*50) + (M/MH*30) + (C/CH*20)}$$

DR = Data Rank
R = Resolution rank for individual source x
RH = Highest rank for resolution in the dataset
M = Methods rank for individual source
MH = Highest rank for method in the dataset
C = Classification rank for individual source
CH = Highest classification rank in the dataset

5 SUMMARY OF DATA SOURCES

For the Study Area, there were 5-point data sources and 18 polygons data sources (including sources integrating numerous constituent data sources; Table 1). Note that equivalent ranks are allowed where polygon data sources do not overlap.

Table 1: Mapping Data Source for Abiotic Substrate Types in the HCTT Study Area

Geometry	Source	Data Rank (0–100)	Description (Rank Components)
PointvPoint[1]	(California State Lands Commission, 2012)	NA	Mapped points representing shipwreck locations, but deleted points coincident with NOAA (2015)
	(Government of Hawaii, 2002)	NA	Mapped points representing shipwrecks offshore Hawaiian Islands
	(National Oceanic and Atmospheric Administration, 2015)	NA	Mapped artificial only (limited to shipwreck, rocky outcrop and unknown object locations regardless of accuracy)
	(Marine Cadastre, 2023)	NA	Mapped points representing artificial reef centroids (replaced Phase III California Department of Fish and Wildlife data)
	(Bureau of Ocean Energy, 2011)	NA	Mapped points representing oil/gas platform centroids and wells
Polygon	(Bauer et al. 2016)	64.6	Digital data: Predictive models of deep-sea coral habitat suitability in the Main Hawaiian Islands (Resolution 3, Methods 3, Classification Compatibility 2)
	(California State University Seafloor Mapping Lab, 1987)	30.8	California continental shelf geology (Resolution 2, Methods 1, Classification Compatibility 2)
	(California State University et al., 2007)	55.8	Predicted Substrate of Southern California (Resolution 4, Methods 3, Classification Compatibility 2)
	(Cochrane, et. al., 2022)	75.0	Derived Benthic Habitat Offshore of South-Central California (Resolution 5, Methods 4, Classification Compatibility 3)
	(KTU-A Landscape Architecture & Planning, Moffatt Nichol, San Diego Nearshore Habitat Mapping Program, & San Diego Association of Governments, 2002)	62.5	Seafloor Substrate of the San Diego Region Nearshore Coastal Zone (Resolution 4, Methods 3, Classification Compatibility 3)
	(Merkel and Associated 2013)	75.8	Benthic Habitat Mapping in the Silver Strand training area of Southern California (Resolution 10, Methods 3, Classification Compatibility 2)
	(Merkel and Associates, 2014)	73.3	Benthic Habitat Mapping for West Cove Naval Auxiliary Landing Field, San Clemente Island Naval Base Coronado, California (Resolution 7, Methods 4, Classification Compatibility 2)

Geometry	Source	Data Rank (0–100)	Description (Rank Components)
	(National Centers for Coastal Ocean Science, 2007b)	60.8	Northwestern Hawaiian Island Shallow-water Coral Reef Ecosystem Map Development Procedures (2004–2007 data) (Resolution 5, Methods 3, Classification Compatibility 2)
	(Pacific Marine & Estuarine Fish Habitat Partnership, 2022)	50.8	West Coast USA Nearshore CMECS Substrate Habitat (Resolution 6, Methods 1, Classification Compatibility 2)
	(Pacific Islands Benthic Habitat Mapping Center, 2016)	73.3	West Maui Benthic Habitat (Resolution 6, Methods 4, Classification Compatibility 2)
	(Pacific Islands Ocean Observing System, 2017)	58.3	West Hawai'i Benthic Habitat (Resolution 6, Methods 4, Classification Compatibility 2)
	(Smith, 2016)	73.3	Hawaii Benthic Habitat (Resolution 6, Methods 4, Classification Compatibility 2)
	(U.S. Geologic Survey, 2012)	80.0	Hueneme Canyon and Vicinity Benthic Habitat (Resolution 6, Methods 4, Classification Compatibility 3)
	(U.S. Geologic Survey, 2018)	80.0	Offshore of Point Conception Benthic Habitat (Resolution 6, Methods 4, Classification Compatibility 3)
	(National Centers for Coastal Ocean Science, 2007a)	87.5	Mapping of Benthic Habitats for the Main Eight Hawaiian Islands (Resolution 7, Methods 3, Classification Compatibility 3)
	U.S. Department of the Navy (2016) – lowest quality unclassified data	27.1	Unclassified sediment mapping from Naval Oceanographic Office (Resolution 1, Methods 1, Classification Compatibility 2)
	U.S. Department of the Navy (2016) – highest quality unclassified data	40.8	Unclassified sediment mapping from Naval Oceanographic Office (Resolution 2, Methods 2, Classification Compatibility 2)
	Wells et al. (2016)	83.3	Substrate Mapping in the Pearl Harbor Channel (Resolution 8, Methods 4, Classification Compatibility 2)

[1] NA = Not Applicable; Points are not assigned a qualitative rank because they did not precisely overlap.

6 DESCRIPTION OF NON-OVERLAPPING MOSAIC

Thousands of acres of low-quality data were superseded by high quality data in the process of creating the non-overlapping abiotic substrate maps for the Study Area. Point features were also included in the dataset because they are inherently non-overlapping in terms of area. Refer to Appendix A (Abiotic Substrate Mapping by Region in the HCTT Study Area) for regional substrate maps from the HCTT EIS/OEIS (note: linkage between Appendix A and B is the “map_id” and “Environmental Data IDFK” field).

Within the HCTT Study Area, a total of 1,355 artificial substrate points were identified (Table 2). Among these 1,355 artificial substrate points, 1,180 were identified as shipwrecks, 166 as artificial reefs, and 9 as oil and gas platforms (Table 2).

The polygon data for abiotic substrate types covers the entire extent of the Study Area (Appendix A), though the quality varied widely. The higher quality mapping data available for the Study Area is confined to shallow margins around the mainland coast, islands and other land features (e.g., atolls). The Pacific Basin Open Ocean Area is mapped with a lower quality dataset (U.S. Environmental Protection Agency, 2016) where bottom habitat is in the abyssal zone, where even deep-sea corals are not expected (Tittensor et al., 2009). Within the Study Area, a much greater portion of bottom is classified as soft (88–92%) than hard (0–5%) (Table 3). However, percent of bottom area does not account for the vertical relief of some hard bottom areas, which contribute disproportionately to hard bottom community biomass.

Table 2: Number and Type of Artificial Substrate Points Documented in the HCTT Study Area

Study Area	Artificial Reef	Shipwreck	Oil/Gas platforms	Grand Total
California	131	554	9	685
Hawaii	35	626	0	661
Grand Total	*166*	*1,180*	*9*	*1355*

Table 3: Area and Percent Coverage of Abiotic Substrate Types in the HCTT Study Area

Study Area	Habitat						Total Area (km^2)
	Hard		Mixed		Soft		
	Area	%	Area	%	Area	%	
California	1,928	0.22	97,210	10.95	788,420	88.83	887,558
Hawaii	420,259	5.35	132,135	1.68	7,300,380	92.97	7,852,774
Area Grand Total	422,187	4.83	229,345	2.62	8,088,800	92.55	8,740,332

7 LITERATURE CITED

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APPENDIX A - Abiotic Substrate Mapping by Region in the HCTT Study Area

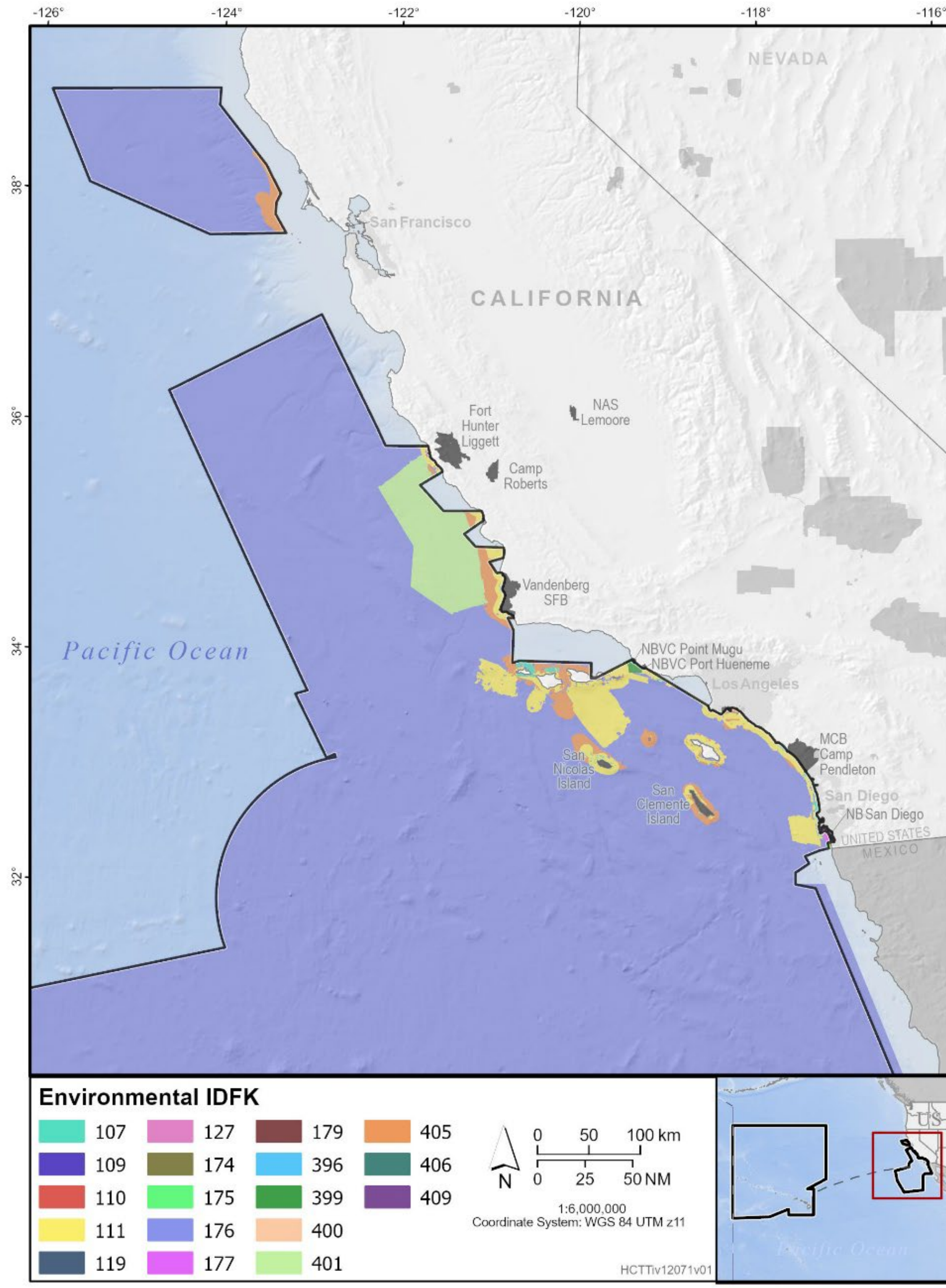

Figure A-1: Distribution of benthic habitat data sources in the Southern California Range Complex (refer to Appendix B to link Environmental Data IDFK to more information). Note: linkage between Appendix A and B is the “map_id” and “Environmental Data IDFK” field

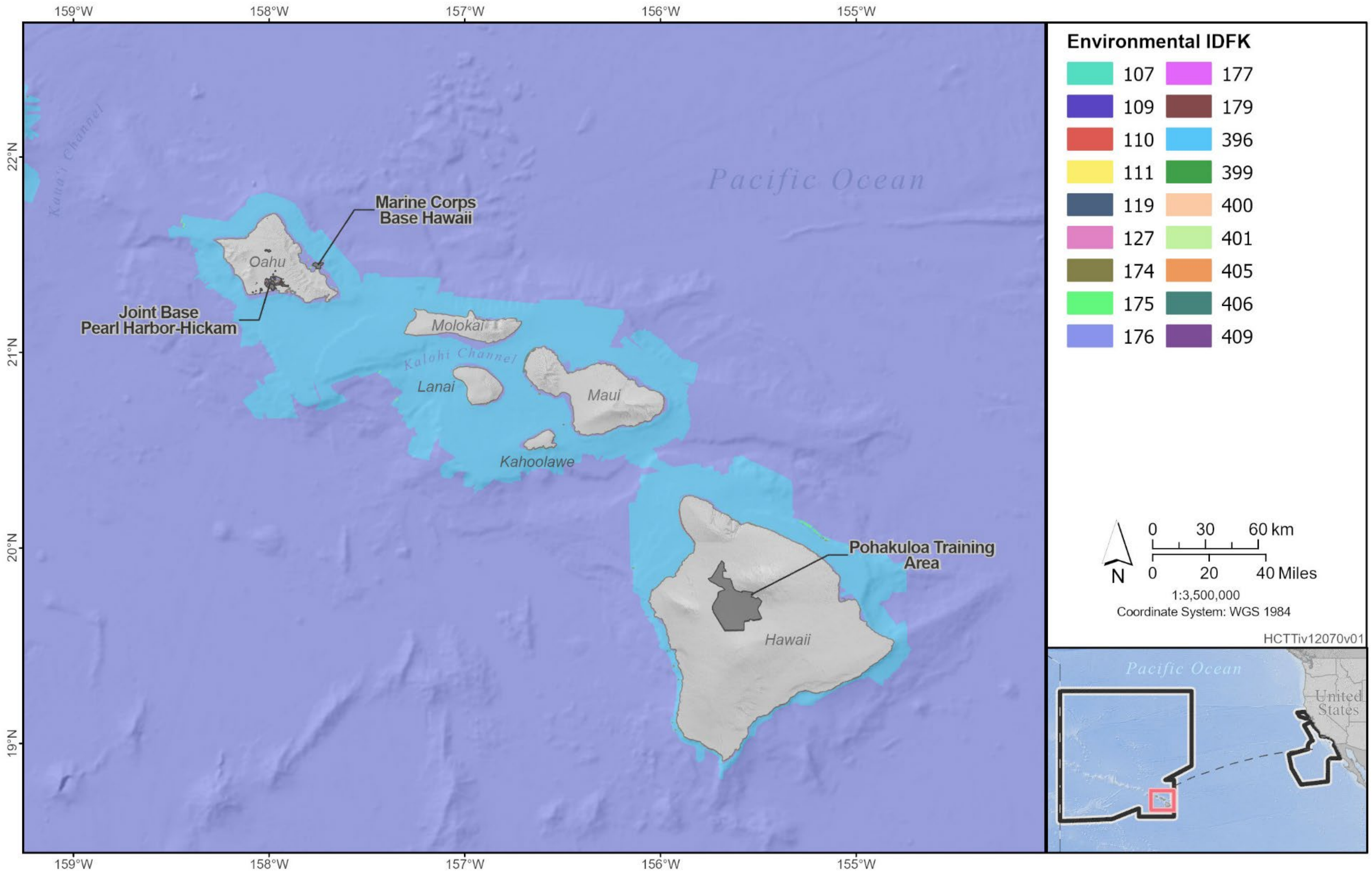

Figure A-2: Distribution of benthic habitat data sources in the Main Hawaiian Islands (refer to Appendix B to link Environmental Data IDFK to more information). Note: linkage between Appendix A and B is the "map_id" and "Environmental Data IDFK" field

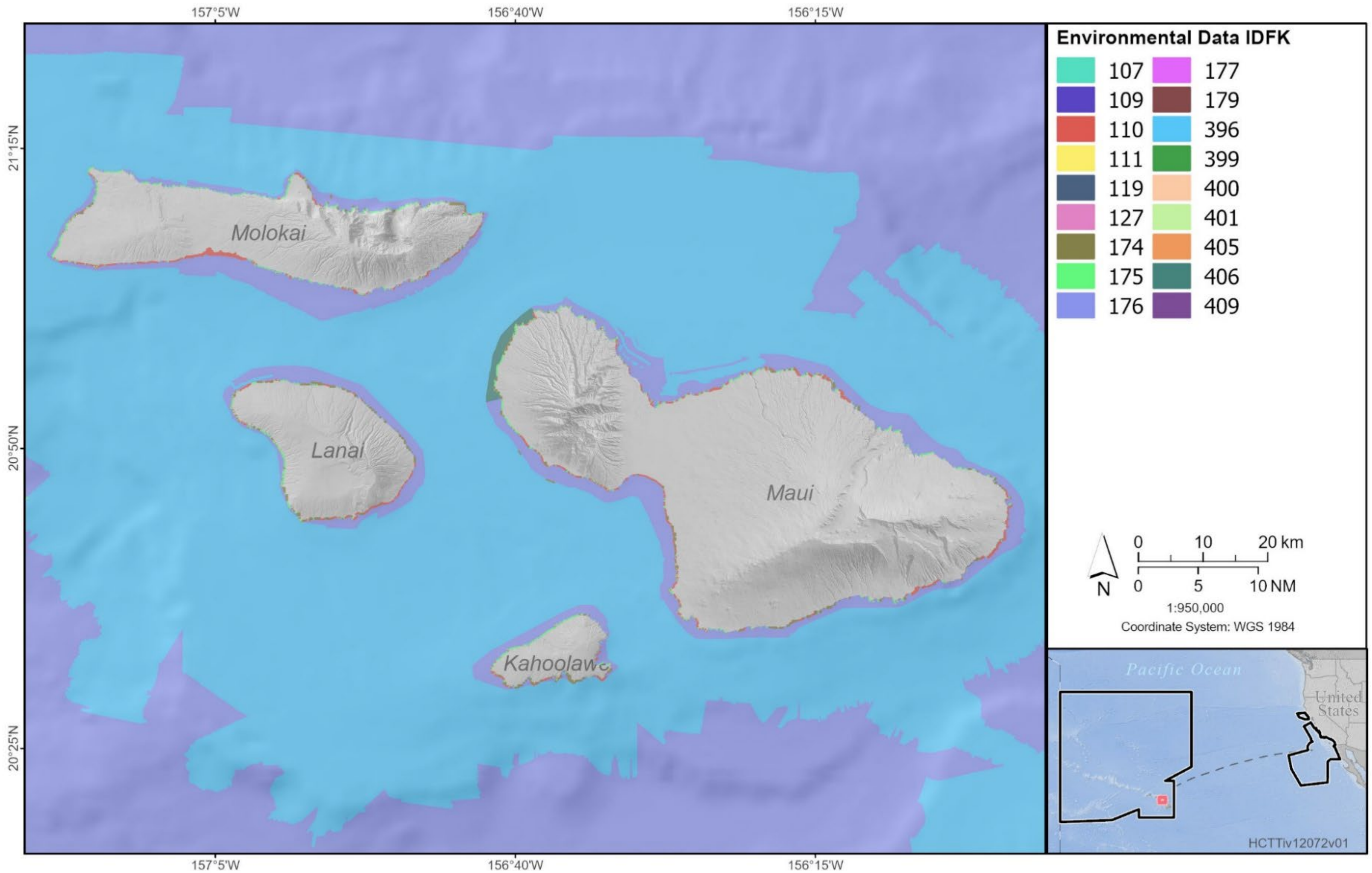

Figure A-3: Distribution of benthic habitat data sources of the Maui, Molokai, and Lanai region (refer to Appendix B to link Environmental Data IDFK to more information). Note: linkage between Appendix A and B is the "map_id" and "Environmental Data IDFK" field

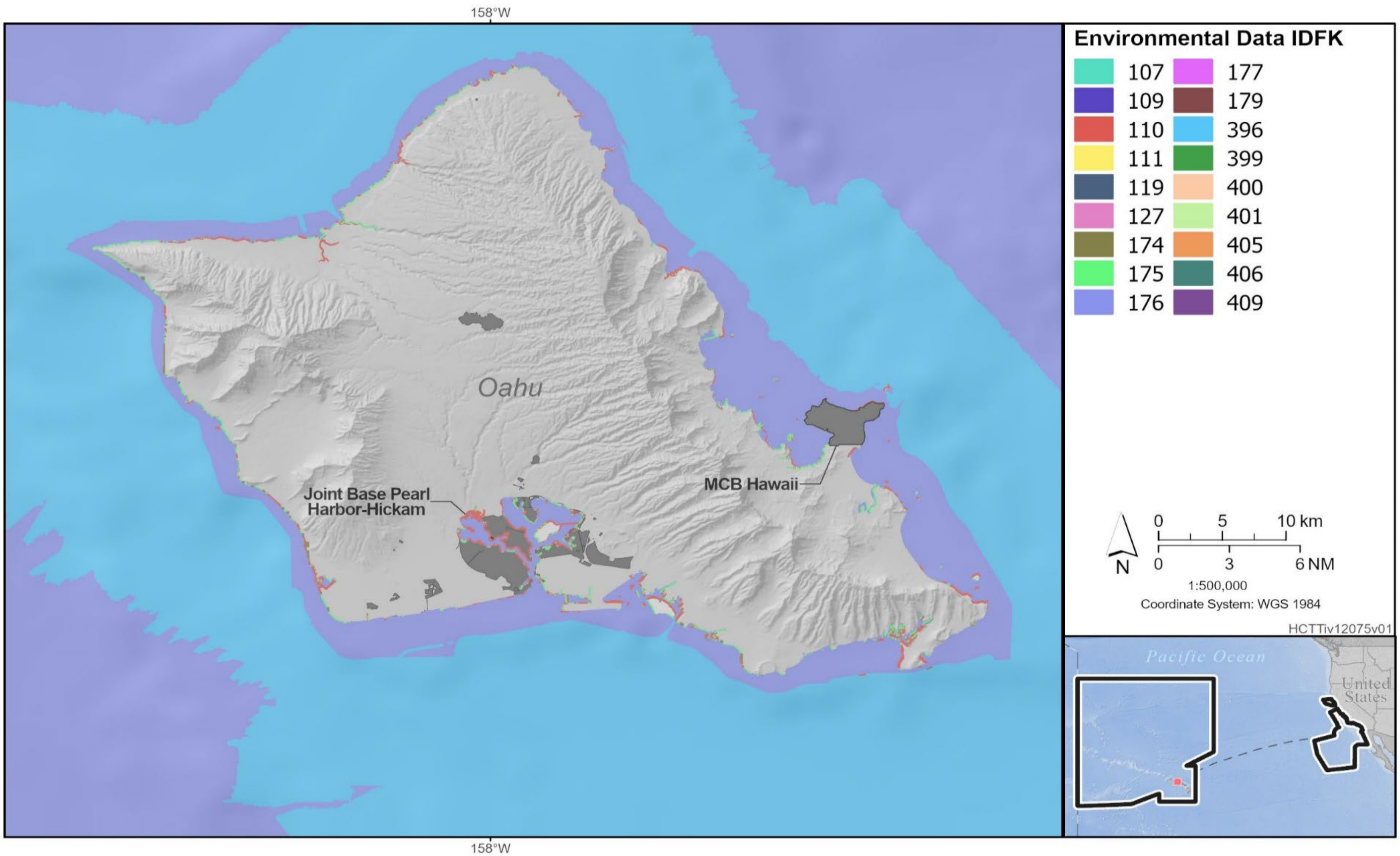

Figure A-4: Distribution of benthic habitat data sources in the Oahu region (refer to Appendix B to link Environmental Data IDFK to more information). Note: linkage between Appendix A and B is the "map_id" and "Environmental Data IDFK" field

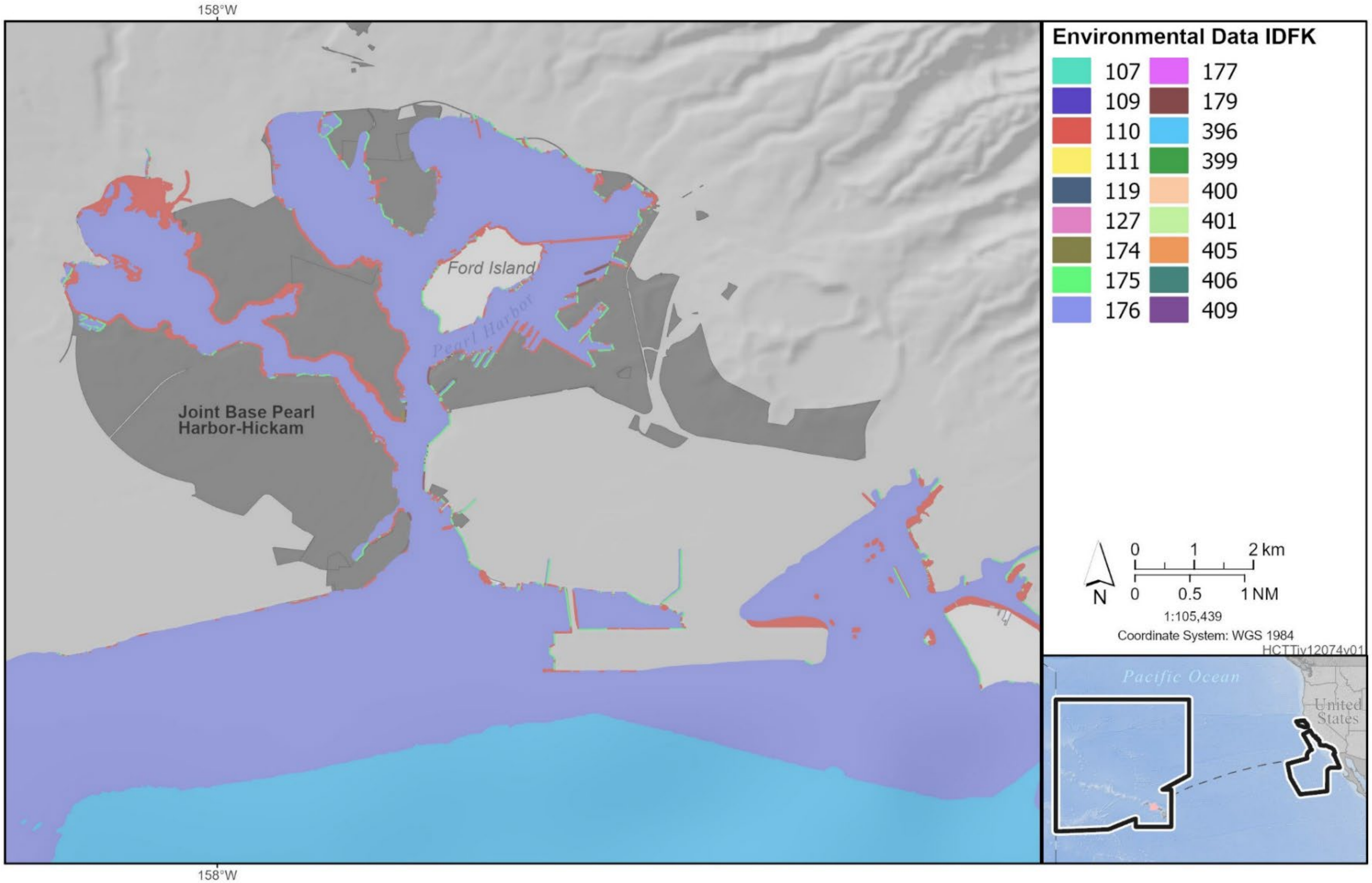

Figure A-5: Distribution of benthic habitat data sources in the Pearl Harbor region (refer to Appendix B to link Environmental Data IDFK to more information). Note: linkage between Appendix A and B is the "map_id" and "Environmental Data IDFK" field

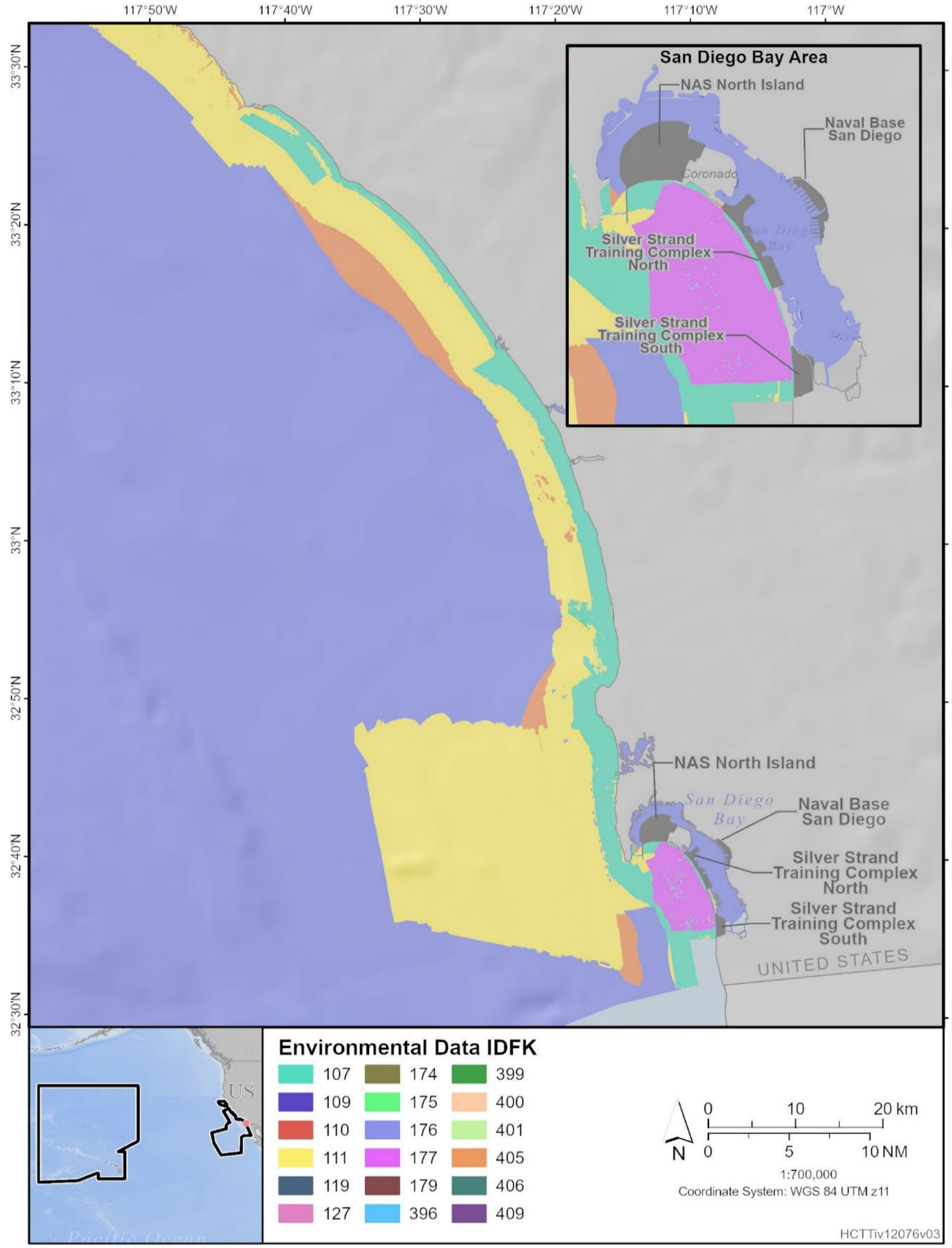

Figure A-6: Distribution of benthic habitat data sources in the San Diego Bay region (refer to Appendix B to link Environmental Data IDFK to more information). Note: linkage between Appendix A and B is the "map_id" and "Environmental Data IDFK" field

APPENDIX B - Data Sources that Support Rank Determinations

Table B-1: Data Source Qualities Supporting Rank Determinations

Data Source - #map_id	Year(s) Data Collected	Method (Mapping)	Method (Validation)	Min. Mapping Unit (m)	Processing Notes
CSU Seafloor Mapping Lab - #109	1987	Bathymetry, Modeling/ interpolation	Benthic Sampler	500	FeatureName: Hard as BOTTOM = "hard_outcrop/pavement" or "hard_bottom"; Mixed as BOTTOM = "mixed"; Soft as BOTTOM = "soft_sediment"
CSUMB, USGS, Fugro Palagos, Ocean Imaging, SanDAG, MLML, CDFW - #111	2006	Acoustic Sensor, Modeling/ interpolation, Spectral Sensor (remote)		15	FeatureName: Hard as 'mapclass' = "Hard"; Soft as 'mapclass' = "Soft"
KTU-A LA and P, MN, SDNHMP, and SanDAG - #107	2002	Acoustic Sensor, Spectral Sensor (remote)		6	FeatureName: Hard as "Bedrock" or "Boulder" or "Kelp Canopy Obscuring Seafloor"; Mixed as "Cobble" or "Pebble/Gravel/Granule"; Soft as "Sand" or "Mud"; Artificial as "Artificial Substrate"
Merkel and Associates - #119	2013	Acoustic Sensor	Visual Observation (direct)	3	FeatureName: Hard as "Rocky Shore- Spray/Splash Zone" or "Boulder Over Bedrock" or "Bedrock"; Mixed as "Mixed Sand/Rubble"; Soft as "Sand"
NCCOS - #127	2004–2007	Spectral Sensor (remote)		10	Hard as "HABCOVER" = 'CCA on hardbottom' OR "HABCOVER" = 'hardbottom, unspecified cover' OR "HABCOVER" = 'live coral on hardbottom' OR "HABCOVER" = 'macroalgae on hardbottom' OR "HABCOVER" = 'uncolonized hardbottom'; Soft as "HABCOVER" = 'macroalgae on unconsolidated' OR “HABCOVER” = “unconsolidated”
NOAA/NOS/NCCOS /CCMA - #110	2007	Spectral Sensor (remote)	Visual Observation (direct)	0.6–4	FeatureName: Hard as 'M_STRUCT'="Coral Reef and Hardbottom"; Soft as 'M_STRUCT'="Unconsolidated Sediment"

Data Source - #map_id	Year(s) Data Collected	Method (Mapping)	Method (Validation)	Min. Mapping Unit (m)	Processing Notes
Bauer et al. - #174	2016	Bathymetry, Modeling/ Interpolation	Acoustic Sensor, Bathymetry, Benthic Sampler, Plankton Sampler, Visual Observation (direct), Water Flow/Quality Meters	400	Converted rasters for deep-sea coral probabilities (0–14 scale) into polygon shapefiles and combined species shapefiles with only the top 75% ranking (>10). The genera included represent precious and stony coral species associated with hard substrate: black corals, gold corals, pink corals, bamboo corals, and frame-building stony corals.
U.S. Department of the Navy - #175 (lower quality) & 176 (higher quality)	2016	Bathymetry, Expert Knowledge, Modeling/ Interpolation	Benthic Sampler	>1000	FeatureName: Hard as "LABEL_1" = 'Calcareous Coral' OR "LABEL_1" = 'Calcareous Rock' OR "LABEL_1" = 'Calcareous Rock - Coral' OR "LABEL_1" = 'Hemipelagic Calcareous Rock' OR "LABEL_1" = 'Hemipelagic Calcareous Rock - Coral' OR "LABEL_1" = 'Hemipelagic Terrigenous Rock' OR "LABEL_1" = 'Terrigenous Rock' OR "LABEL_1" = 'Volcanic Boulders' OR "LABEL_1" = 'Volcanic Rock' OR "LABEL_1" = 'Hemipelagic Calcareous Rock - Sand - Mud' OR "LABEL_1" = 'Calcareous Rock - Sand - Mud' OR "LABEL_1" = 'Calcareous Rock - Sand' OR "LABEL_1" = 'Terrigenous Rock - Gravel - Sand' OR "LABEL_1" = 'Calcareous Rock -
					Gravel' OR "LABEL_1" = 'Calcareous Rock - Gravel - Sand' OR "LABEL_1" = 'Pelagic Calcareous Marl'; Mixed as "LABEL_1" = 'Calcareous Coral Debris' OR "LABEL_1" = 'Calcareous Coral Debris - Mud - Shell' OR "LABEL_1" = 'Calcareous Gravel - Sand' OR "LABEL_1" = 'Calcareous Gravelly Sand - Shell' OR "LABEL_1" = 'Hemipelagic Calcareous Coral Debris' OR "LABEL_1" = 'Hemipelagic Calcareous Coral Debris - Sand' OR "LABEL_1" = 'Hemipelagic Calcareous Coral Debris - Sand - Mud' OR "LABEL_1"

Data Source - #map_id	Year(s) Data Collected	Method (Mapping)	Method (Validation)	Min. Mapping Unit (m)	Processing Notes
					= 'Hemipelagic Calcareous Coral Debris - Sand - Shell' OR "LABEL_1" = 'Hemipelagic Calcareous Gravel - Sand' OR "LABEL_1" = 'Hemipelagic Calcareous Gravel (Shell Detritus)' OR "LABEL_1" = 'Hemipelagic Calcareous Gravelly Sand - Shell' OR "LABEL_1" = 'Hemipelagic Terrigenous Clay' OR "LABEL_1" = 'Hemipelagic Terrigenous Gravel - Mud' OR "LABEL_1" = 'Pelagic Calcareous Gravel' OR "LABEL_1" = 'Pelagic Clay' OR "LABEL_1" = 'Pelagic Siliceous Clay' OR "LABEL_1" = 'Volcanic Gravel' OR "LABEL_1" = 'Pelagic Calcareous Clay' OR "LABEL_1" = 'Hemipelagic Calcareous Sandy Gravel' OR "LABEL_1" = 'Terrigenous Gravel - Silty Sand' OR
					"LABEL_1" = 'Calcareous Coral Debris Sand' OR "LABEL_1" = 'Calcareous Coral Debris - Sand - Mud' OR "LABEL_1" = 'Calcareous Coral Debris Sand - Mud - Shell' OR "LABEL_1" = 'Calcareous Coral Debris - Sand - Shell'; Soft as:"LABEL_1" = 'Calcareous Clayey Silt' OR "LABEL_1" = 'Calcareous Gravelly Muddy Sand' OR "LABEL_1" = 'Calcareous Gravelly Sand'OR "LABEL_1" = 'Hemipelagic Calcareous Gravelly Muddy Sand' OR "LABEL_1" = 'Hemipelagic Terrigenous Gravelly Sand' OR "LABEL_1" = 'Terrigenous Gravelly Sand' OR "LABEL_1" = 'Terrigenous Gravelly Sandy Silt'
Merkel et al. - #177	2012	Acoustic Sensor	Acoustic Sensor, Expert Knowledge	1	FeatureName: Hard as "boulder/cobble reef"; Mixed as "coarse sediments/shell hash"; Soft as "sand"; Artificial as "artificial substrate";

Data Source - #map_id	Year(s) Data Collected	Method (Mapping)	Method (Validation)	Min. Mapping Unit (m)	Processing Notes
					Unknown as "unknown target"
Wells et al. - #179	2015	Acoustic Sensor	Visual Observation (direct)	2.5	Converted raster coverages into polygons and classified gridcode ranges to standardized abiotic substrate types: hard = 63–126, mixed = 126–189, soft = 189–254. The reference indicated that range of gridcode values was essentially a uniform gradient from 0–100% hard or soft.
Smith - #396	2016	Spectral Sensor (remote)	Spectral Sensor (remote)	5	Converted from raster to vector. Hard bottom Classification based on Smith 2016 values. Data simplified and data noise deleted out using ArcGIS; FeatureName: Hard as “Live Hard Bottom”; Soft as “Soft Bottom”
U.S. Geological Survey, - #399	2012	Spectral Sensor (remote)	Visual Observation (Direct)	5	FeatureName: Hard as “unidentified anthropogenic”, “anthropogenic breakwater”, “consolidated rock”, “pipeline anthropogenic unconsolidated sediment”; Soft as “scoured/unconsolidated sediment”, “unconsolidated sediment”, “rippled/unconsolidated”, “pockmark/unconsolidated”, “rippled/current scoured/unconsolidated sediment”, “dredge disturbance/unconsolidated sediment”, “hummocky/unconsolidated sediment”
U.S. Geological Survey, - #400	2018	Spectral Sensor (remote)	Visual Observation (direct)	5	FeatureName: Hard as “asphalt”, “artificial pipeline”, “bedrock”; Mixed as “thin marine sediment covering bedrock”; Soft as “marine sediment”, “fine sediment”, “slope”
Cochrane et. al., - #401	2012	Acoustic Sensor	Modeling/Interpolation, Visual Observation (direct)	10	FeatureName: Hard as “hard”; Mixed as “mixed”; Soft as “soft”

Data Source - #map_id	Year(s) Data Collected	Method (Mapping)	Method (Validation)	Min. Mapping Unit (m)	Processing Notes
Pacific Marine & Estuarine Fish Habitat Partnership- #405	2022	Bathymetry, Modeling/Interpolation	Modeling/Interpolation	5	FeatureName: Hard as “11 rock substrate”, “111 bedrock”, “12111 boulder”, “3 anthropogenic substrate”, “32 anthropogenic wood” ; Mixed as “1211 gravel”, “12112 cobble”; Soft as “12 unconsolidated mineral substrate”, “12131 gravelly sand”, “122 fine unconsolidated substrate”, “1222 sand”, “12223 medium sand”, “1224 sandy mud”, “12242 sandy silty clay”, “1225 mud”
Pacific Islands Benthic Habitat Mapping Center, - #406	2016	Acoustic Sensor, Bathymetry	Modeling/Interpolation, Visual Observation (direct)	5	FeatureName: Hard as “complex reef”, “pavement”; Mixed as “mixed substrate”, “rubble”; Soft as “sand”
Pacific Islands Ocean Observing System, - #409	2017	Bathymetry	Expert Knowledge	5	FeatureName: Hard as “complex reef”, “pavement”, “boulder”, “manmade”; Mixed as “mixed substrate”, “rubble”; Soft as “sand”

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