Marine Protected Areas within the Clarion-Clipperton Zone

Charles L Morgan
Moana Hohonu Consulting, LLC
94-452 Mūlehu Street, Mililani HI 96789 USA
www.Moanahohonu.com
Charles@moanahohonu.com

ABSTRACT

In 2012 the International Seabed Authority (ISA) established nine "Areas of Particular Environmental Interest" (APEIs) for consideration as future Marine Protected Areas to help preserve the biodiversity of life on the seabed within the Clarion-Clipperton Zone (CCZ) between Baja California, Mexico, and the Hawaiian Islands. The CCZ is believed to have a high potential for future seabed mining operations. Areas under active exploration contracts in the CCZ, plus the areas currently reserved by the ISA for exploration by developing nations, comprise about 1.9 million km^2 of seabed area. The currently designated APEIs consist of more than 1.4 million km^2 of seabed. Each APEI includes a central primary conservation area of 200 X 200 km, surrounded by 100-km buffer areas on all sides. The 100-km buffers are intended as a very conservative spacing between the primary conservation area and potential mining activities in adjacent seabed.

The selection of these nine 400 X 400 km APEIs, has been criticized as possibly not including sufficient representative habitat similar enough to the potential mining areas (identified currently as the exploration contract and reserved areas administered by the ISA within the region) to ensure protection of the biodiversity that might be impacted by mining.

An area to the east of the existing exploration contracts and reserved areas is known to have substantial mineral deposits; it is very similar to the adjacent exploration contract areas in its geology, environmental setting, polymetallic nodule abundance and nodule metal content. Because it is located in the northeastern extreme of the CCZ, this area is also likely to have relatively high densities of benthic life, compared with benthic communities further westward within the CCZ. Many options for the designation of this APEI are possible, but the area designation must accommodate the boundaries of the Exclusive Economic Zones of Mexico and France.

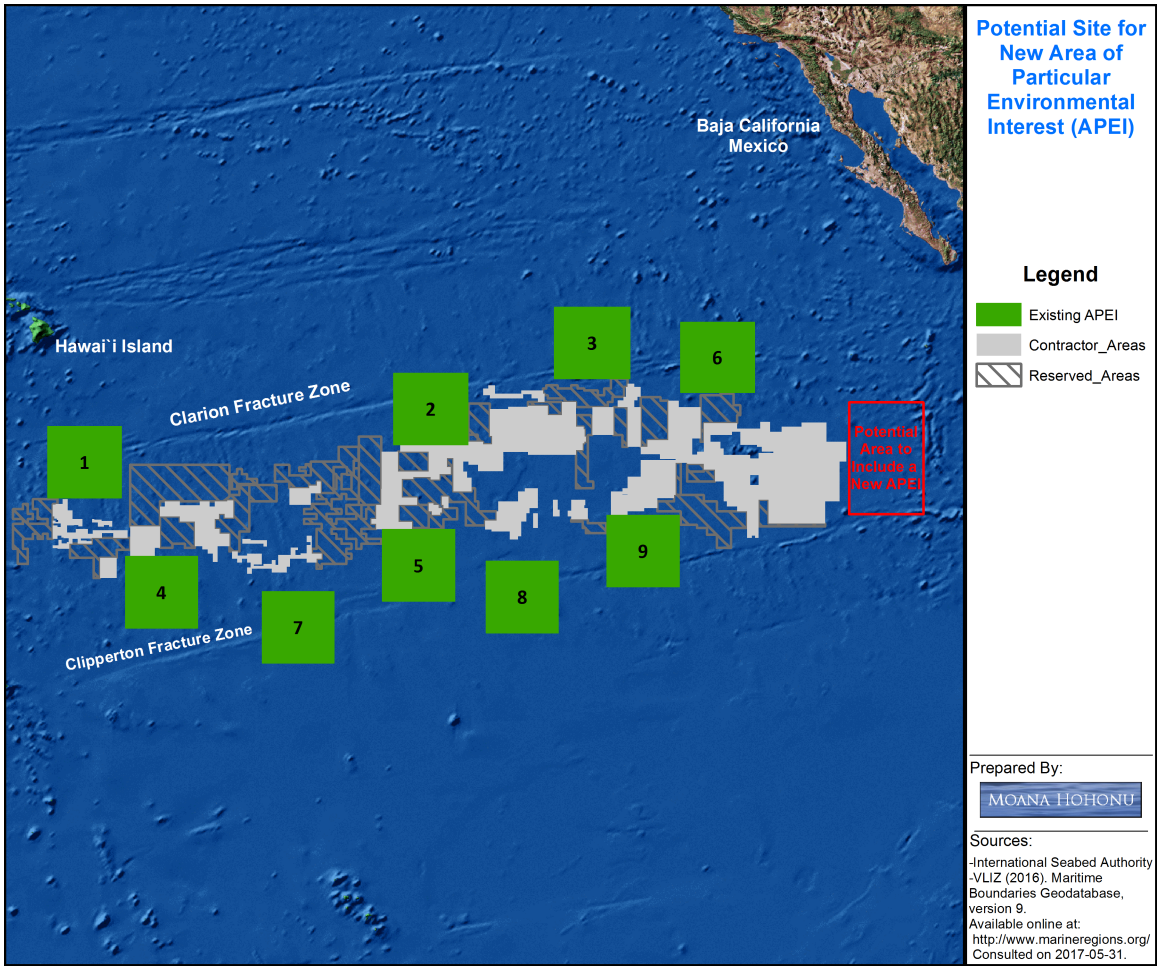
This paper discusses why the selected region in the eastern extreme of the CCZ is a good candidate for designation as a new APEI.

Keywords: polymetallic nodules, Marine Protected Areas, Clarion-Clipperton Zone, Areas of Particular Environmental Interest

INTRODUCTION

In 2012 the International Seabed Authority (ISA) established (ISA 2012) nine "Areas of Particular Environmental Interest" (APEIs) for consideration as future Marine Protected Areas (MPAs) to help preserve the biodiversity of life on the seabed within the Clarion-Clipperton Zone (CCZ) between Baja California, Mexico, and the Hawaiian Islands (Figure 1).

Figure 1 ISA Areas of Particular Environmental Interest



The CCZ is believed to have a high potential for future seabed mining operations. This paper proposes that the ISA consider some portion of the area shown in red in Figure 1 as a candidate region for locating a new APEI. The following section discusses the general background and concept of APEIs in the CCZ, as developed by the ISA. The subsequent section outlines the results of field experiments and numerical modeling that simulated the impacts of mining and the relevance of this work to the specification of the buffer zone for MPAs. The final section discusses the justification for the creation of an additional APEI and key characteristics relevant to its designation.

BACKGROUND AND CONCEPT

Marine Protected Areas

The 7th Conference of the Parties to the Convention on Biological Diversity (CBD) defined "marine and coastal protected area" as "*any defined area within or adjacent to the marine environment, together with its overlying waters and associated flora, fauna and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection that its surroundings"* (CBD 2004).

Thus, according to this definition Marine Protected Areas (MPAs) serve primarily to protect marine biodiversity and can include various levels of protection, ranging, for example, from limited bans on fishing particular species to absolute prohibition of any human activities in the defined area. In 2015, the 193 member-States of the United Nations confirmed their commitment to conserve at least 10 percent of coastal and marine areas by 2020, incorporating a target established under the CBD into the UN's 2030 Agenda for Sustainable Development (Pew Charitable Trust 2016).

In a specific examination of the efforts by the International Seabed Authority's (ISA) efforts to develop MPAs in the Clarion-Clipperton Zone (CCZ), Wedding et al. (2015) asserted the following:

> *MPA networks support a precautionary approach for managing ecosystems where data are limited (e.g., in the deep sea) by preserving replicated portions of diverse habitats and associated biodiversity and ecosystem function, in situations where exploitation may cause serious, unpredictable, and potentially irreversible damage. The efficacy of individual MPAs to protect biodiversity and critical habitats has been well documented in the marine environment, and MPA networks further safeguard against uncertainty and promote ecosystem connectivity in the face of environmental degradation.*

MPAs in the CCZ

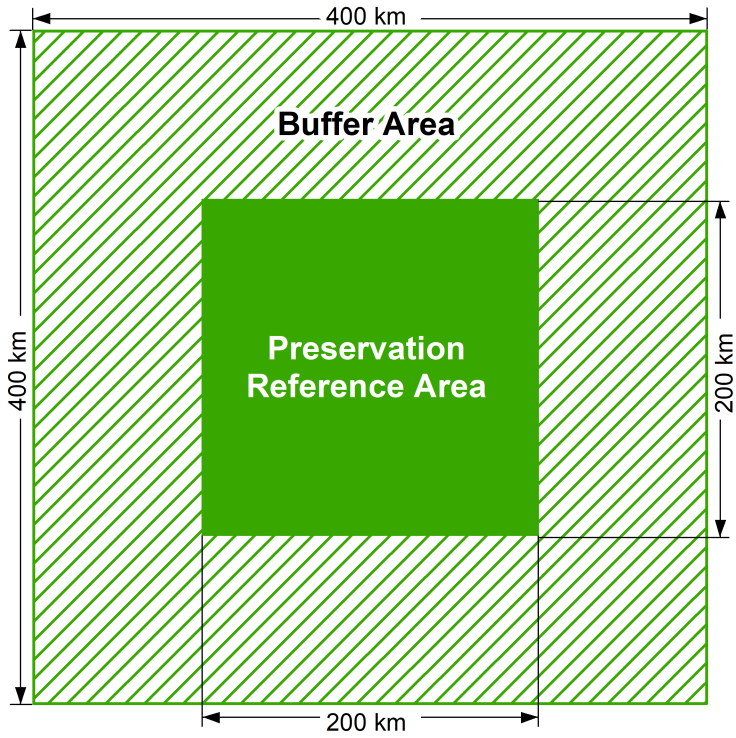
In 2007 the Pew Charitable Trust sponsored a workshop (Smith and Koslow 2007) to facilitate the design of MPAs for Pacific seamounts and the abyssal Pacific nodule region (specifically, the CCZ). This workshop recommended the establishment of a network of MPAs within the CCZ. Each MPA would consist of a "Preservation Reference Area"[1] (PRA) of 200 km^2 X 200 km^2, which would be isolated by a surrounding 100-km buffer to protect the PRA from potential environmental impacts caused by mining in adjacent seabed areas (Figure 2).

The ISA's 2012 designation of nine APEIs, each defined as being 400 km X 400 km, was based on the 2007 workshop recommendations, and is the first step in the process of establishing a network of MPAs within the CCZ. Areas under active exploration contracts

[1] Under current ISA regulations PRAs are also required to be designated within each exploration contract area, but these PRAs will not be able to be buffered from potential mining activities as effectively as the 100-km buffers designated for the APEIs.

in the CCZ, plus the areas currently reserved by the ISA for exploration by developing nations, comprise about 1.9 million km^2 of seabed area. The currently designated APEIs cover 1.44 million km^2 of seabed.

Figure 2 Proposed Marine Protected Area Design for the CCZ



THE MPA BUFFER

The specification of a 100-km buffer surrounding the PRA defined in the 2007 workshop has no basis in field observations or reasonable technical extrapolation. The distance was selected as a very conservative assumption, which could accommodate potentially wide dispersion of sea-surface discharges of mining-related suspended sediments.[2] Currently, no exploration contractor is proposing to dump mining tailings in surface discharges, which would have serious implications related to the London Convention (1972) and can easily be avoided by proper engineering design of the mining system.

In the 1980s and 1990s five separate field simulations of mining impacts were conducted in the CCZ, the Indian Ocean, and the Peru Basin off South America. Review of the

[2] Personal recollections of this paper's author, who was directly involved with the specification of this parameter at the 2007 workshop.

results of these experiments, which cumulatively suspended up to 3,600 tons of sediments 1 to 5 m above the seabed, shows that impacts were observed within the reach of the device used for creating the disturbance and immediately adjacent to the tracks of the device. No impacts were documented more than a few tens of meters from the tracks in any of these experiments (Jones 2000).

Jones et al. (2017) completed an excellent review of these experiments and subsequent examinations of these test sites, as well as a review of field testing at sites where international consortia carried out tests of prototype mining systems in the 1970s. This review concluded that the maximum distance detected of any impacts of the experiments and mining tests was about 250 m, though most studies reviewed concurred with the Jones (2000) conclusions, that impacts from suspended sediments occur at no more than a few tens of meters from the direct impact site. Numerical dispersion modeling that includes the effects of sediment flocculation suggest that potential dispersion effects might occur up to 1 to 2 km from the mining site (Jankowski and Zielke 2001).

JUSTIFICATION FOR AND LOCATION OF AN ADDITIONAL APEI

Justification for an Additional APEI

About one year after the ISA designated its network of APEIs, a group of scientists proposed three alternate arrangements of the APEI locations (Wedding et al. 2013), suggesting that the alternates would be more representative of the seabed habitats in the CCZ that are currently proposed for potential mining. The selection criteria for these alternates included known locations of seamounts, polymetallic nodule abundance, and estimated flux of particulate organic nitrogen from surface waters to the seabed.

Unfortunately, these alternate locations overlap significantly with areas reserved specifically for potential exploitation by developing nations, rendering their adoption by the ISA difficult if not impossible. Nevertheless, Wedding et al. (2013) raise a legitimate concern. Because the designation of APEI locations occurred after the issuance of exploration contracts and the establishment of reserved areas comprising a significant portion of the CCZ, locations of the APEIs were relegated mostly to the margins of the region (see Figure 1).

The additional APEI proposed here is selected to mitigate this concern by including an area that is clearly representative of existing exploration contracts and that hosts a relatively high abundance of deep-seabed fauna. The characteristics of the suggested location relevant to its designation as an APEI are described in the following section.

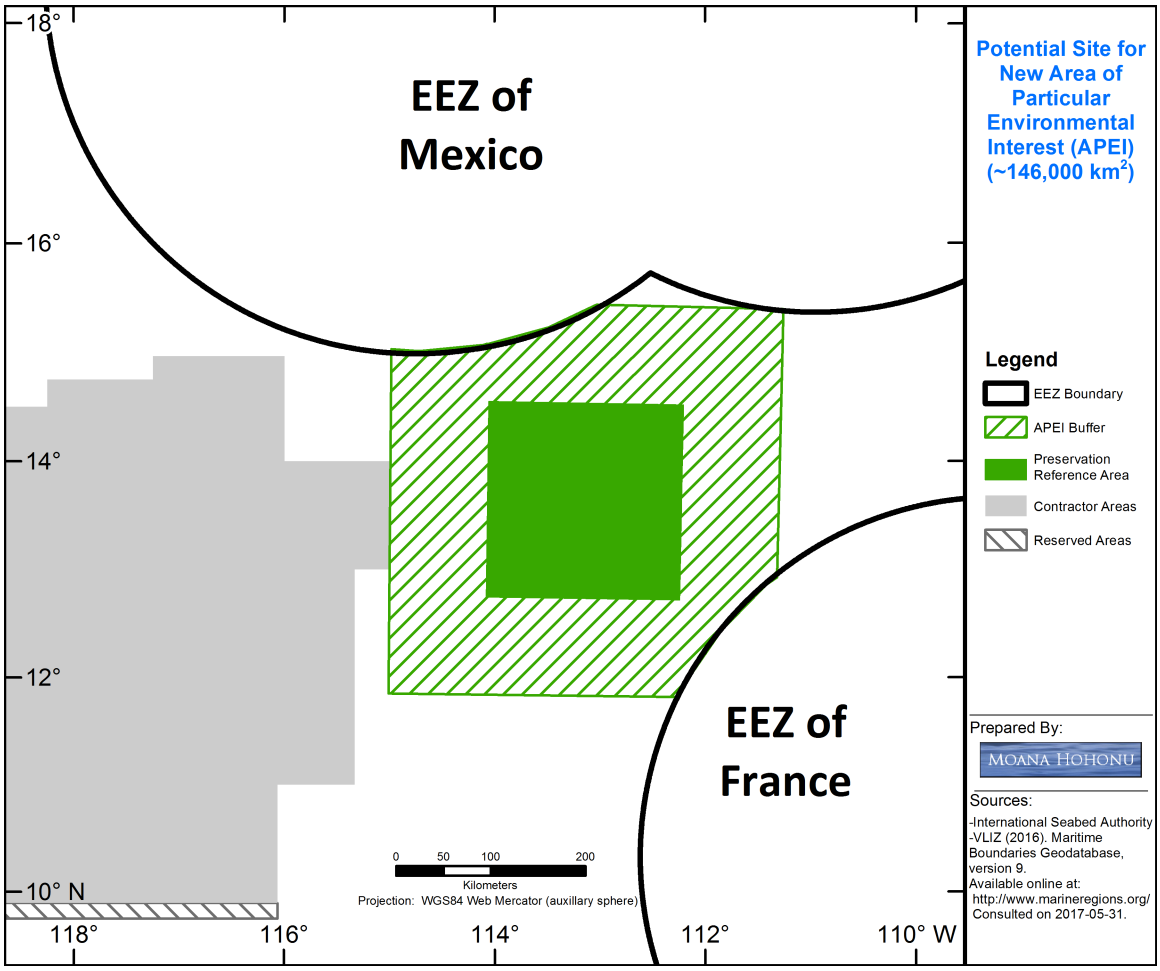
Site Characteristics of Proposed APEI

The area proposed here to be designated as a new APEI is shown in Figure 3. It is adjacent to the UKSR and OMS[3] exploration contract areas to the west and truncated partially on the north and south by, respectively, EEZ areas of Mexico and France. The

[3] UKSR: United Kingdom Seabed Resources, Ltd.; OMS: Ocean Mineral Singapore, Pte Ltd.

minimum distances between the PRA in the center of the area and the boundaries with the Mexican and French EEZs are, respectively, 54 and 51 km.

Figure 3 Proposed New APEI for the CCZ



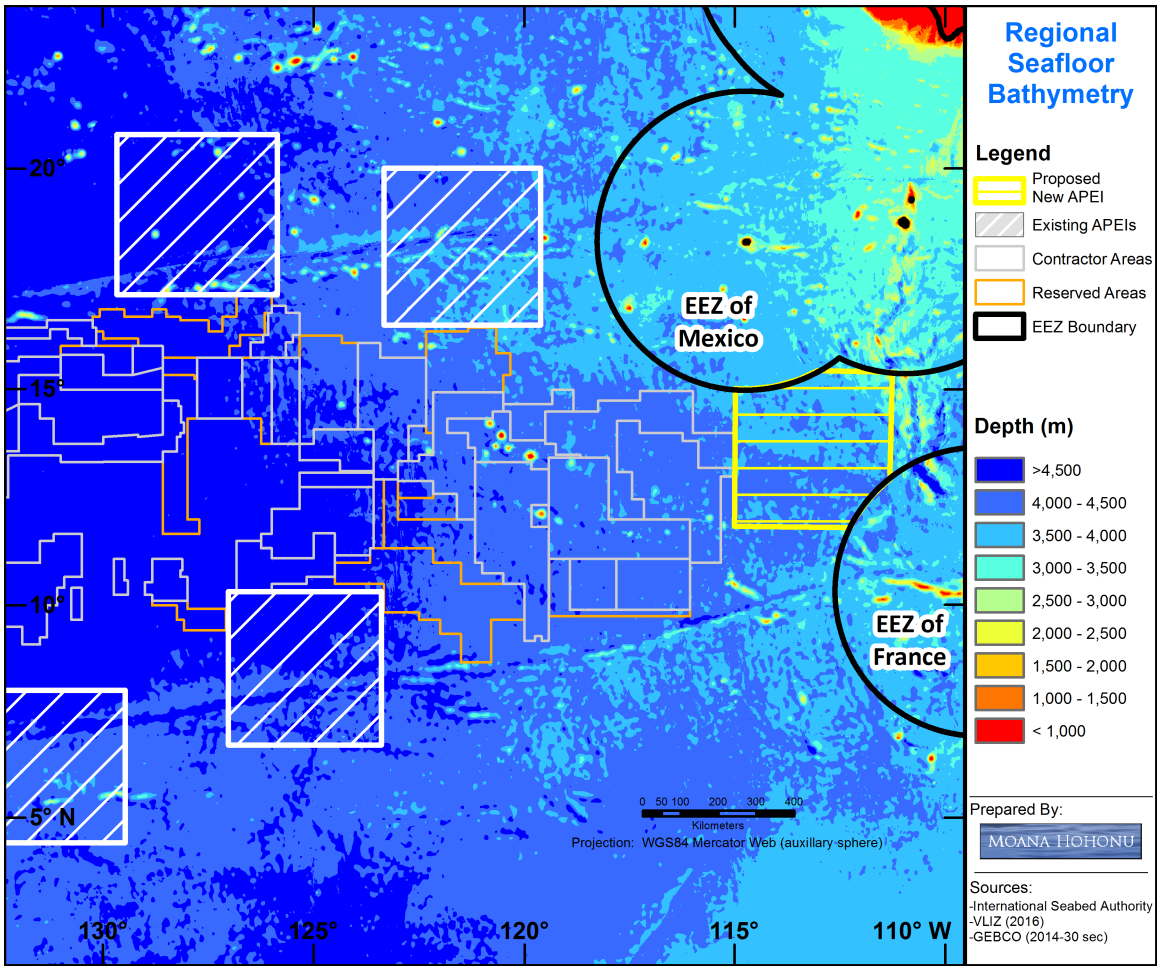
As discussed above, field experiments that examined the results of deliberate dispersion of sediments on the seafloor and numerical modeling of such dispersion indicate that mining impacts from this cause are not expected to extend beyond 1 to 2 km. Thus, the truncation of the buffer areas suggested in this figure should not jeopardize the maintenance of pristine conditions within the PRA, assuming that potential mining activities within the Mexican or French EEZ areas are conducted in a reasonable manner, consistent with international law.

As discussed below, this area has a number of positive attributes that would make it a good selection for a new APEI, including geomorphology, relatively high densities of benthic life, and mineral resource abundance and metal content that are representative of existing areas under exploration contracts,.

Regional Geomorphology

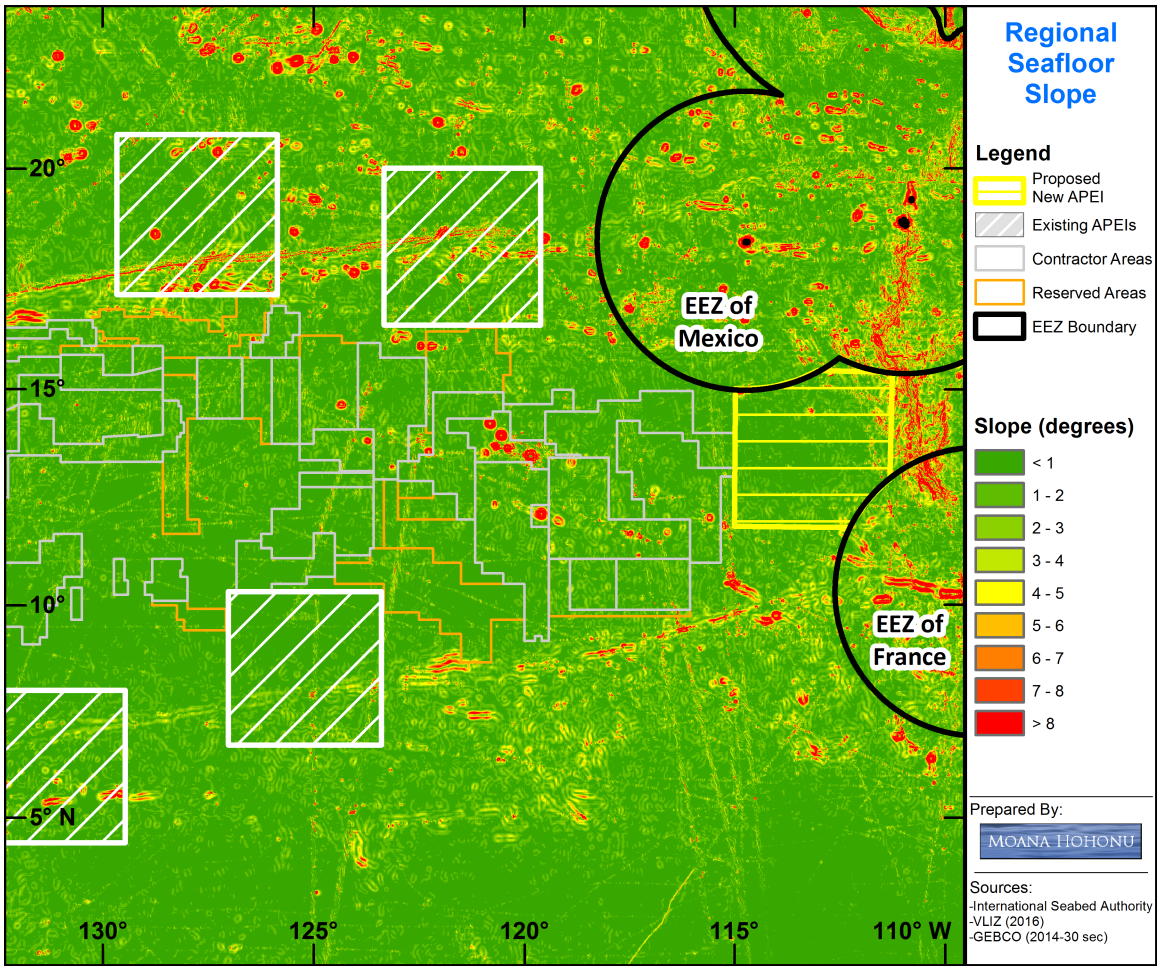
In this study, geomorphology is characterized by bathymetry, seafloor slope, and seafloor roughness. The regional bathymetry (GEBCO 30 arc-second map; BODC 2014) adjacent to and to the west of the proposed APEI is presented in Figure 4. As shown in this figure, the APEI site is located at the extreme eastern end of the CCZ. To the west-southwest, the depth gradually increases between the Clarion Fracture Zone to the north and the Clipperton Fracture Zone to the south; this region hosts all the ISA polymetallic nodule exploration claims in the Pacific. To the north, south, and east, the bathymetry shoals relatively steeply to the islands that define the Mexican and French EEZs to the north and south and the East Pacific Rise to the east.

Figure 4 Regional Bathymetry



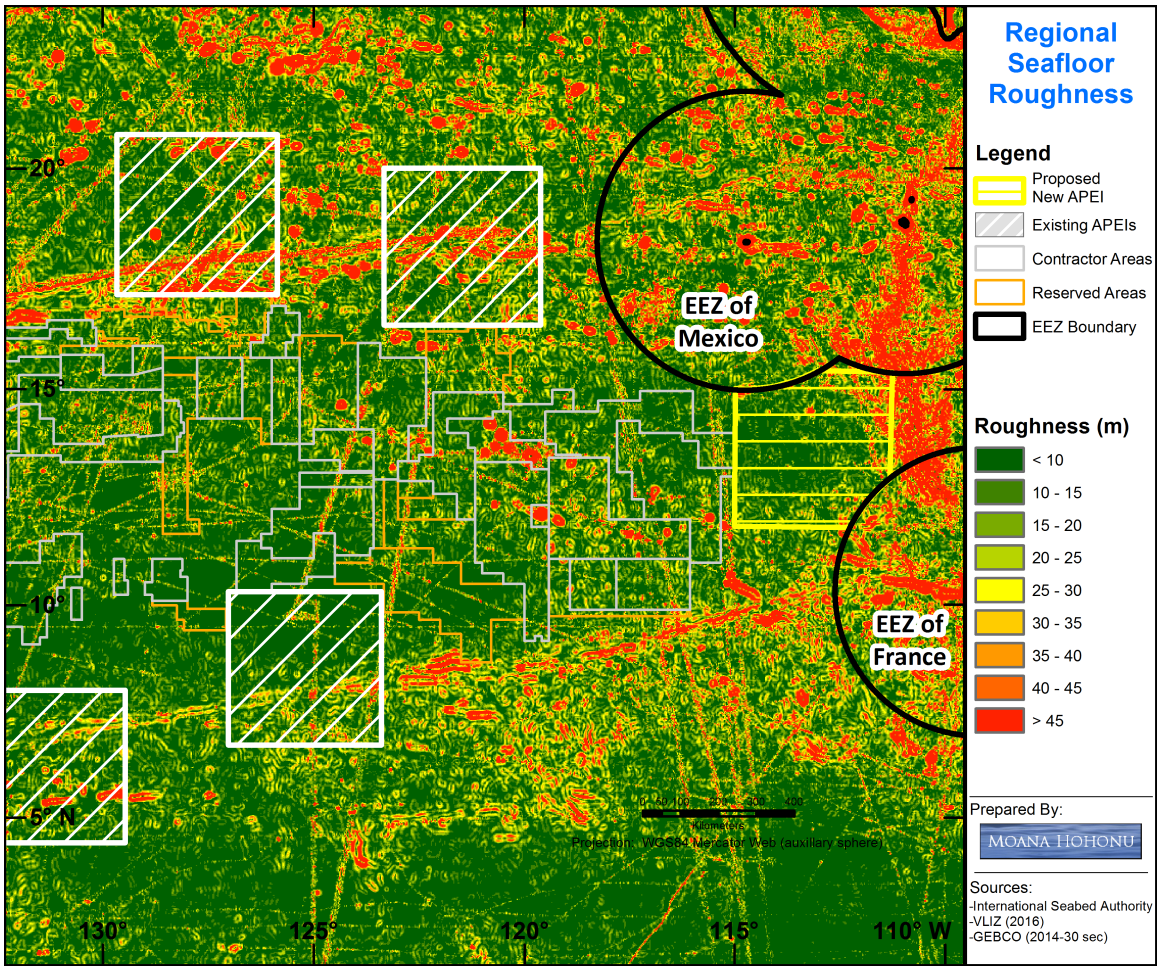
Seafloor slopes in this region (Figure 5) are consistent with the characterization of the proposed APEI site as the eastern extreme of the CCZ. As with most of the CCZ, regional slopes rarely exceed 3-4 degrees, with the occasional exception of seamounts. The slopes in this figure are estimated as the maximum slope for each pixel with neighboring pixels. Pixel dimensions for this projection of the GEBCO data are 900m X 900m.

Figure 5 Regional Seafloor Slopes



Regional seafloor roughness (or rugosity) is estimated here (Figure 6) as the standard deviation of water depth within each 3-pixel X 3-pixel area (i.e. 2.7 km X 2.7 km areas). Again, the proposed new APEI area is similar to the CCZ seafloor to the west, with relatively low roughness (< 15 m) exhibited in most of the area, interrupted primarily in the northeastern buffer by rougher areas.

Figure 6 Regional Seafloor Roughness



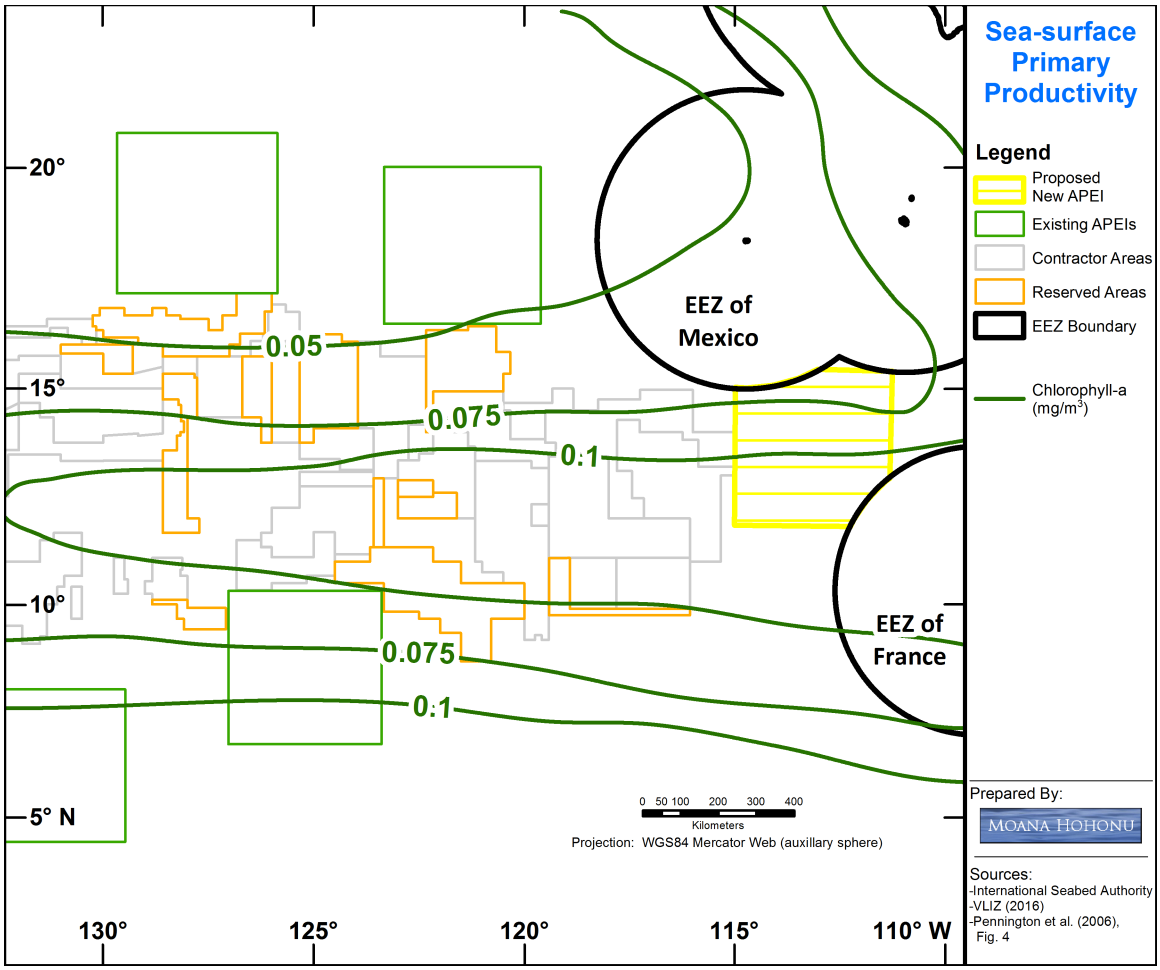
Benthic Biological Communities

Seafloor biological communities in the CCZ are detrital food webs, ultimately deriving their sustenance from organic matter that settles to the seabed from the surface waters above. To date, no evidence for persistent hydrothermal activity, seeps of methane gas, or other potential energy sources to support benthic life have been documented in the CCZ. In these deep-ocean oligotrophic waters, the flux of organic matter to the seafloor is dependent upon the primary productivity in surface waters, often represented by the concentration of chlorophyll in these waters.

In the CCZ, primary productivity generally decreases from east to west, reflecting the progressive decline of nutrient concentrations carried by surface currents from terrigenous sources in North and Central America; productivity increases from north to south, because of the continuous increase of sunlight reaching surface waters with decreasing distance from the equator. Pennington et al. (2006) integrated chlorophyll data from testing of seawater sample collections and indirect determinations deduced from sea-surface color collected by satellite optical scanning (Figure 7). The apparent anomaly exhibited in this figure to the general trends outlined above (i.e. the relative maximum between 10° - 13°N)

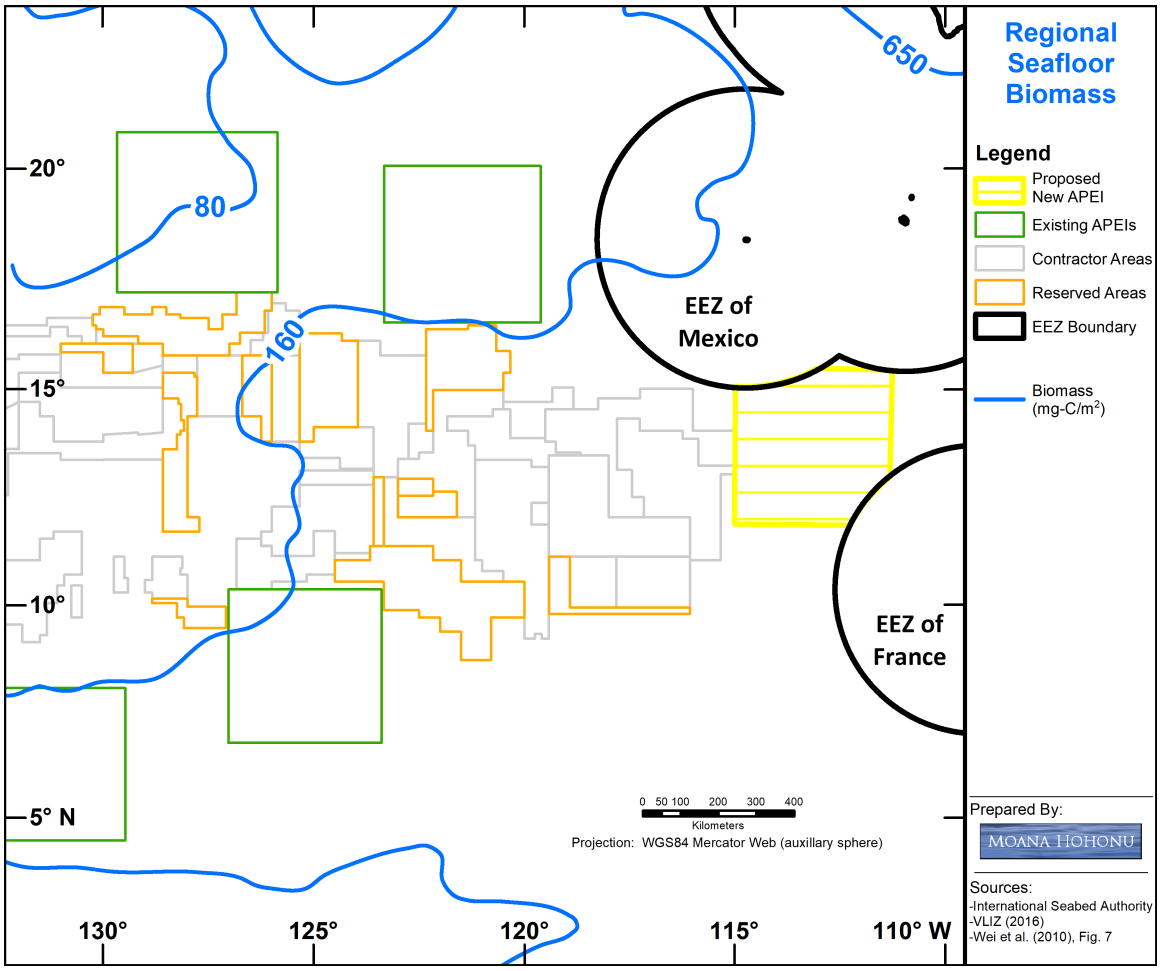
is believed to be the result of relatively strong upwelling of nutrients along the coast of Central America within the Gulf of Papagayo (10.7°N).

Figure 7 Primary Productivity in the Eastern CCZ



Wei et al. (2010) used the scanty available measurements of seafloor biomass with predictor variables such as chlorophyll levels in surface waters, water depth, estimates of organic carbon fluxes to the seafloor, bottom-water temperature and other variables in a novel computer model (Random Forests; Breiman 2001) to produce a global map of seafloor biomass density. Figure 8 is extracted from this work for the area of interest in this study. The predicted seafloor biomass differs from the primary production estimates in that the relative maximum biomass lies several degrees to the south of the apparent surface productivity maximum, but the decreasing east-to-west values are consistent between the two, supporting the contention that the proposed APEI location is likely to represent the highest seafloor biomass occurring within the CCZ.

Figure 8 Distribution of Seafloor Biomass



In the deep seabed, the relationships between biodiversity and biomass in benthic ecosystems are poorly understood. The biodiversity of benthic fish species clearly declines with depth and benthic biomass (Priede and Froese 2013). In contrast, the biodiversity of the polychaetes, foraminifera, and other macrofauna resident within and on seabed sediments is generally high in the prime areas of nodule abundance, despite very low levels biomass. High biodiversity in these macrofaunal communities does not imply high levels of biological productivity or resilience to changing environmental conditions.

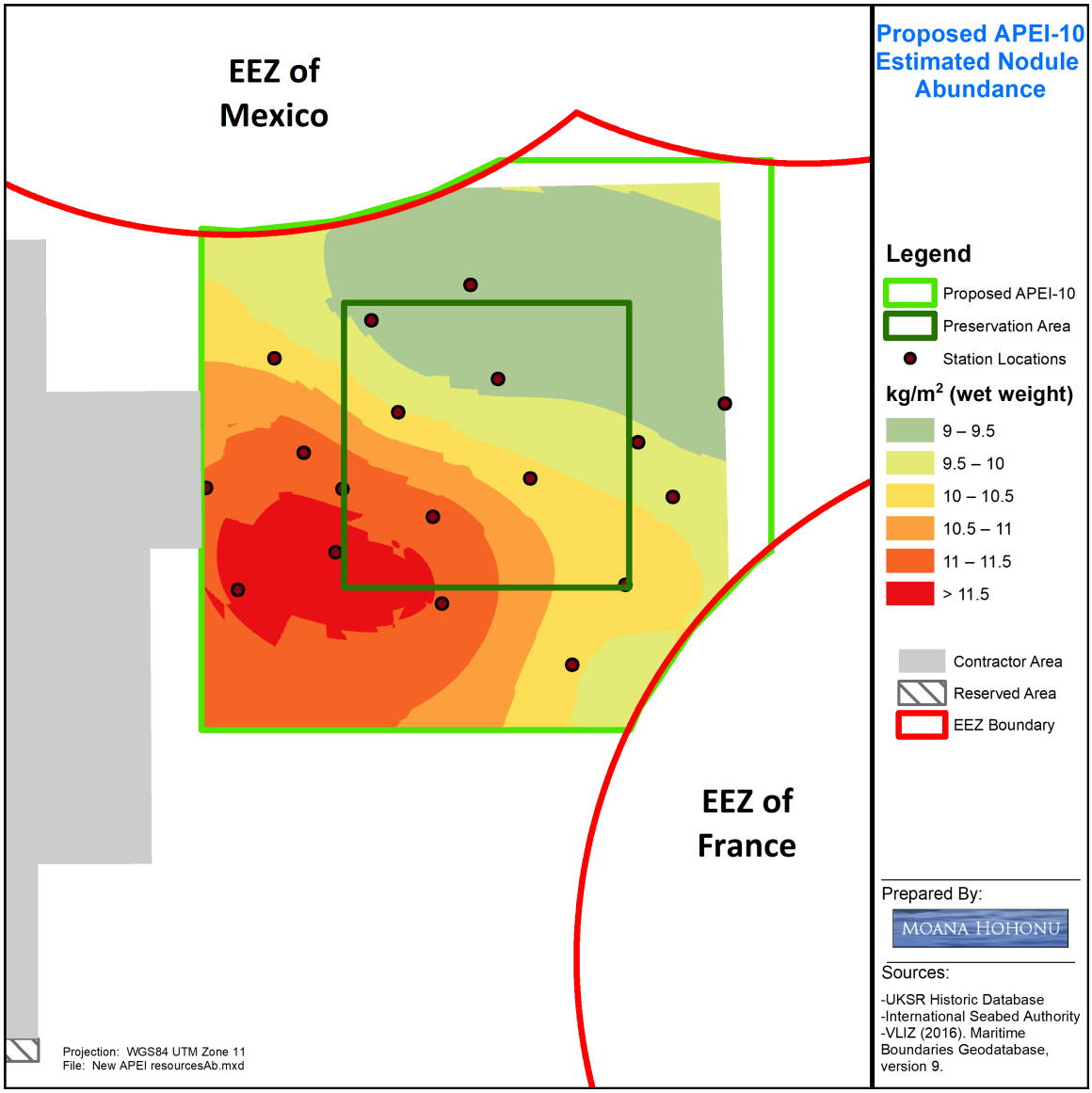
Hardy, Smith and Thurnherr (2015) note that, in addition to the regional trends noted above, macrofauna communities in the CCZ are likely to be dependent on nearby, relatively high abundance communities to supply spores, larvae, and other forms of benthic dispersion for recruiting new organisms into these food-limited communities. Thus, the proposed APEI, which is likely to host the most abundant benthic communities within the CCZ, should be considered seriously as an addition to the existing APEI areas.

Polymetallic Nodule Resources

Historic data on the polymetallic nodule abundance and nickel concentration within the proposed new APEI were made available for this study by the United Kingdom Seabed

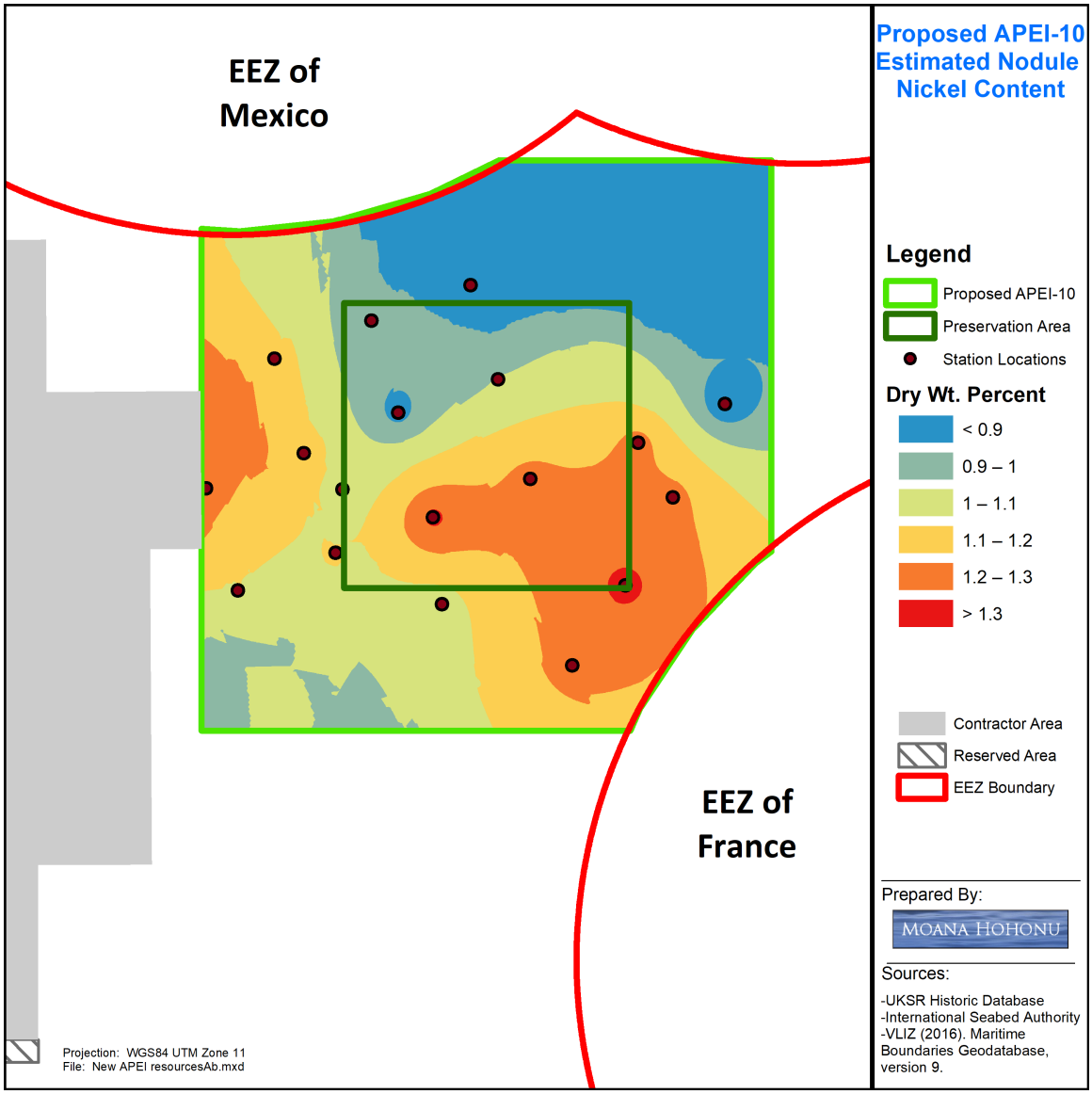
Resources, Ltd. (UKSR), an exploration contractor with the ISA with a claim area adjacent to the proposed new APEI (Spickermann 2017). The plot of nodule abundance (Figure 9) was derived from the collection of 144 samples from 30 station locations, within and in the vicinity of the proposed new APEI. The plot of nodule nickel content (Figure 10) was derived from 179 samples collected from 35 stations. The 18 stations located within the proposed APEI are shown in these figures.

Figure 9 Polymetallic Nodule Abundance in the Proposed New APEI



The interpolations for these plots were calculated using Empirical Bayesian kriging techniques[4] (Krivoruchko 2012). The values for nodule abundance and nickel content are in the upper levels of the ranges of values found within the existing contractor areas (see ISA 2010).

Figure 10 Polymetallic Nodule Nickel Content in the Proposed New APEI



[4] Mean values used for each station location; Empirical transformation, K-Bessel variogram;

SUMMARY

In 2012 the International Seabed Authority established nine "Areas of Particular Environmental Interest" (APEIs) for consideration as future Marine Protected Areas to help preserve the biodiversity of life on the seabed within the Clarion-Clipperton zone (CCZ) between Baja California, Mexico, and the Hawaiian Islands. The currently designated APEIs consist of more than 1.4 million km^2 of seabed. Each APEI includes a central primary conservation area of 200 X 200 km, surrounded by 100-km buffer areas on all sides. The 100-km buffers are intended as a very conservative spacing between the primary conservation area and potential mining activities in adjacent seabed.

The selection of these nine 400 X 400 km APEIs, has been criticized as possibly not including sufficient representative habitat similar enough to the potential mining areas (identified currently as the exploration contract and reserved areas administered by the ISA within the region) to ensure protection of the biodiversity that might be impacted by mining.

An area to the east of the existing exploration contracts and reserved areas is known to have substantial mineral deposits; it is very similar to the adjacent exploration contract areas in its geomorphology, expected composition of benthic biological communities, and polymetallic nodule abundance and grade. Because it is located in the northeastern extreme of the CCZ, this area is also likely to have relatively high densities of benthic life, compared with benthic communities further westward within the CCZ. The proposed area is an excellent candidate for the immediate designation as a new APEI and, ultimately, as a Marine Protected Area.

References Cited

BODC (British Ocean Data Center). 2014. *GEBCO 30-arc-second Grid*, Accessed July 8, 2017. URL: https://www.bodc.ac.uk/data/hosted_data_systems/gebco_gridded_bathymetry_data/

Breiman, L. 2001. Random Forests, Machine Learning, 45(1), p. 5-32. URL: http://www.math.univ-toulouse.fr/~agarivie/Telecom/apprentissage/articles/randomforest2001.pdf

CBD (Convention on Biological Diversity). 2004. Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, Kuala Lumpur, Malaysia, 9 - 20 February 2004. URL: https://www.cbd.int/decision/cop/?id=7742#_ftn11

Hardy, S.M., C.R. Smith, and A.M. Thurnherr. 2015. Can the source –sink hypothesis explain macrofaunal abundance patterns in the abyss? A modelling test. *Proceedings of the Royal Society B* 282, 9 p. URL: http://rspb.royalsocietypublishing.org/content/282/1808/20150193

ISA (International Seabed Authority). 2010. Biogeochemical Model of the Manganese, Copper and Nickel Content in Polymetallic Nodules in the Clarion□Clipperton Zone, Chapter 5 in: *Geological Model of Polymetallic Nodule Deposits in the Clarion*□

Clipperton Fracture Zone, ISA Technical Study No. 6, URL: https://www.isa.org.jm/sites/default/files/files/documents/tstudy6.pdf

ISA (International Seabed Authority). 2012. *Decision of the Council relating to an environmental management plan for the Clarion-Clipperton Zone*, ISBA/18/C/22. URL: https://www.isa.org.jm/files/documents/EN/18Sess/Council/ISBA-18C-22.pdf

Jankowski, J.A. and W. Zielke. 2001. The mesoscale sediment transport due to technical activities in the deep sea. *Deep-Sea Research Part II*. 2001; 48(17–18): p. 3487–521 URL: http://s3.amazonaws.com/academia.edu.documents/45528616/The_mesoscale_sediment_transport_due_to_20160510-15790-aq6tr4.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1500152684&Signature=X8izktglKh%2BvEKgbJeNsLD1ZHOI%3D&response-content-disposition=inline%3B%20filename%3DThe_mesoscale_sediment_transport_due_to.pdf

Jones, A.T. 2000. Review of Benthic Impact Experiments Related to Seabed Mining, *Offshore Technology Conference,* OTC 12042, May 1-4, 2000, 4 p.

Jones, D.O.B., S. Kaiser, A.K. Sweetman, C.R. Smith, L. Menot, A. Vink, D. Trueblood, J. Greinert, D.S.M. Billett, P. Martinez Arbizu, T. Radziejewska, R. Singh, B. Ingole, T. Stratmann, E. Simon-Lledó, J.M. Durden, M.R. Clark. 2017. Biological responses to disturbance from simulated deep-sea polymetallic nodule mining, *PLoS ONE* 12(2): 26 p. URL: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0171750

Krivoruchko, K. 2012. *Empirical Bayesian Kriging Implemented in ArcGIS Geostatistical Analyst,* ESRI; 6 p. URL: http://www.esri.com/NEWS/ARCUSER/1012/files/ebk.pdf

London Convention. 1972. *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.* United Nations. URL: https://www.epa.gov/sites/production/files/2015-10/documents/lc1972.pdf

Pennington, J.T., K.L. Mahoney, V.S. Kuwahara, D.D. Kolber, R. Calienes, and F.P. Chavez. 2006. Primary production in the eastern tropical Pacific: A Review, *Progress in Oceanography* 69 p. 285–317. URL: https://www.researchgate.net/publication/239926536_Primary_production_in_the_eastern_tropical_Pacific_A_review

Pew Charitable Trusts. 2016. *Marine Protected Areas Beyond National Jurisdiction*, A View from the Pew Charitable Trusts, March 2016. URL: www.pewtrusts.org/~/media/assets/2016/03/high-seas-mpa-policy-brief.pdf

Priede, I.G. and R. Froese. 2013. Colonization of the deep sea by fishes, *Journal of Fish Biology,* 83, p. 1528-1550.

Rolinski S., J. Segschneider, J. Sundermann. 2001. Long-term propagation of tailings from deep-sea mining under variable conditions by means of numerical simulations. *Deep-Sea Research II* 48, p. 3469–3485.

Smith, C.R. and J.T. Koslow. 2007. URL: *Proceedings, PEW Workshop: Design of Marine Protected Areas for Seamounts and the Abyssal Nodule Province in Pacific High Seas*, University of Hawai‘i at Mānoa, 23-26 October, 2007, 53 p. URL:

http://www.soest.hawaii.edu/oceanography/faculty/csmith/MPA_webpage/documents/Proceedings_PEW_Workshop_MPAs_October_2007.pdf

Spickermann, R. 2017. Personal Communication on August 1, 2017. For further information about these sample collections contact UKSR directly at christopher.j2.williams@lmco.com

VLIZ (2016). Maritime Boundaries Geodatabase, version 9. http://www.marineregions.org/ Consulted on 2017-05-31.

Wedding, L.M., A.M. Friedlander, J.N. Kittinger, L. Watling, S.D. Gaines, M. Bennett, and S. M. Hardy. 2013. From principles to practice: a spatial approach to systematic conservation planning in the deep sea, *Proceedings of the Royal Society B, Biological Sciences,* 280, 11 p. URL: http://rspb.royalsocietypublishing.org/content/280/1773/20131684.short

Wedding, L.M., S.M. Reiter, C.R. Smith, K.M. Gjerde, J.N. Kittinger, A.M. Friedlander, S.D. Gaines, M.R. Clark, A.M. Thurnherr, S.M. Hardy, and L.B. Crowder. 2015. Managing mining of the deep seabed: Contracts are being granted, but protections are lagging. *Science,* 349(6244), p. 144-145. URL: http://www.researchgate.net/publication/279966280

Wei, C.L., G.T. Rowe, E. Escobar-Briones, A. Boetius, T. Soltwedel, M.J. Caley, Y. Soliman, F. Huettmann, F. Qu1, Z. Yu, C.R. Pitcher, R.L. Haedrich, M.K. Wicksten, M.A. Rex, J.G. Baguley, J. Sharma, R.Danovaro, I.R. MacDonald, C.C. Nunnally, J.W. Deming, P. Montagna, M. Le´vesque, J.M. Weslawski, M. Wlodarska-Kowalczuk, B.S. Ingole, B.J. Bett, D.S.M. Billett, A. Yool, B.A. Bluhm, K. Iken, and B.E. Narayanaswamy. 2010. Global Patterns and Predictions of Seafloor Biomass Using Random Forests, *PLoS ONE*, December 2010, 5(12), 15 p. URL: http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0015323&type=printable

Charles L. Morgan

Charles Morgan is the Principal at Moana Hohonu. He obtained a BA degree in Chemistry from the University of California, San Diego and a PhD in Oceanography and Limnology from the University of Wisconsin, Madison. He has worked on marine and coastal projects related to resource development for more than 30 years. He has managed and worked on environmental impact assessments for coastal and marine developments in Hawai‘i, Tarawa, Tonga, the Gulf of Mexico, and for mineral resource developments for seabed deposits in areas outside of any national jurisdiction.

Morgan is a Registered Member of the Society for Mining, Metallurgy & Exploration (SME) and is a Qualified Person for the completion of formal mineral resource assessments for deep seabed mineral deposits of polymetallic nodules. He was the Technical Chair of the annual Underwater Mining Conference between 1991 and 2015. He is the author of numerous professional publications related to seabed mineral resource assessment and environmental impact assessment of deep seabed mining. He was the only U.S. representative to date on the International Seabed Authority Legal and Technical Commission (1997–2001); a member of the U.S. Department of the Interior Outer Continental Shelf Policy Committee (2006-2008); and was the President of the International Marine Minerals Society (1991–1994).