REPLIES BY THE AUTHOR IN BOLD, BLUE FONT

CC1: 'Comment on essd-2021-345', Barbara Mauz, 22 Nov 2021
I truly enjoyed reading this well-written paper. It exemplifies how to review a subject and how to link early ideas to today's thinking. Notwithstanding, after around half of the text I was puzzled.

Thank you for your kind comments and I am glad you enjoyed reading it. I am sorry to hear that halfway through it you were puzzled.

With the Walis project aims in mind, i.e. standardising model-independent approaches for determining sea-level index points: what exactly is the RSL indicator here? Is it a marine terrace, a coral terrace, a shoreline angle?

Depending on where you are, geographically, the RSL indicator is different things. Over most of the Pacific Coast of North America, from southern Canada almost to southern Baja California, the RSL is the shoreline angle of an *erosional* marine terrace. South of there, where *constructional* coral reef terraces can be found (although rarely), it is more complex. In some places, there are erosional marine terraces (i.e., wave-cut benches, with shoreline angles), but coral reefs may have grown ON the wave-cut terrace. Thus, in those situations, you may have two RSL indicators, the shoreline angle AND the paleo-sea level that would be implied by the depth range of the taxa within the coral reef. But, even there, the shoreline angle is the better one, as it is very close to mean sea level, as discussed in the text.

Ok, the angle is a clear concept and easy to identify in the field (unless it is covered by slope deposits as depicted in Fig. 3) but how is the spatial relationship defined between the fossil dated, the terrace surface and the shoreline angle? In Fig. 3 a "*simple*" and a "*complex*" case of a marine terrace is depicted and the terrace deposit is composed of pebbles and (transported?) molluscs fossils. The complex case would be the one where an additional terrace forms above the lower one, hence the subsiding coast is the complex example. What about uplifting coasts and reef platforms? None of the U-series dated corals was in primary growth position suggesting that the sample was collected from the subtidal reef slope or interior platform.

I'm glad that you understand the concept of a shoreline angle, because that is crucial to much of this review. I believe I have explained the concept sufficiently in the text and there are diagrams and photographs showing both modern and ancient ones.

Fig. 3b was intended to show how two marine terraces could be masked by overlying deposits to appear as if only one terrace is present. The lower terrace apparent only in cross section is younger than the upper terrace; thus, this is not (as you describe) a subsiding coast, but an uplifting coast. I have modified the figure caption a bit to make this clear.

As for the fossils, yes, on most the Pacific Coast of North America, north of southern Baja California anyway, virtually all mollusks and corals are transported. Hardly anything is ever in growth position on this high-energy coast. This is very similar to what I have observed in Spain (Canary Islands and Mallorca) and Italy (Sardinia), so I am surprised you have not observed this yourself with your experience in the Mediterranean. Do these transported fossils have *exactly* the same age as the wave-cut bench and its associated shoreline angle? Clearly, they cannot be *exactly* the same age, because the bench has to have formed first (at least initially) and anything on top of it (sand, gravel, fossils) has to have been deposited there later. Having said that, the bench and the fossils are certainly close in age, and any difference in age is likely not capable of being resolved with the dating methods we currently have in use. We see this in the age of beach-collected corals on the modern Pacific Coast, where these specimens yield U-series ages of only a few hundred years, indicating a time of growth similar to the age of the modern wave-cut bench, which is still forming.

You mention "subtidal reef slope" with regard to these corals: that does not apply here. These are tiny, solitary, ahermatypic corals (see Fig. 8a); they do not form reefs. On the open (outer) Pacific Coast, you have to get as far south as southernmost Baja California (see Fig. 7a) before you find large colonial corals, and only from there south do you find hermatypic corals that build reefs.

Fig. 6 illustrates the method approach using photos from the LACMIP locality – how does this approach relate to WALIS? How do pholads allow to estimate max shoreline angle elevation? I do not find the terms 'bench' and 'pholads' in Rovere et al.

This is all explained in the text. "Bench" (in this context meaning *wave-cut* bench) has been a geomorphic term in use for decades and is well understood by geomorphologists everywhere. "Wave-cut bench" appears in the AGI "Glossary of Geology" (5th edition, 2011) on page 720. "Pholad" refers to bivalve mollusks of the family Pholadidae, which are the rock-boring mollusks. This is one of the very few examples of fossils that can sometimes be found in growth position, because they are still found in the holes that they themselves bored in the bench. Some of these taxa have specific depth ranges, such as *Penitella penita*, the example I used. It is typically found in waters less than 10 m deep. Thus, if

you find it in growth position in fossil form, you are no lower than 10 m below the former shoreline associated with that fossil.

I can't answer the question about why "bench" and "pholad" do not appear in Rovere et al., but the terms have been around for decades and are well established.

Does this affect the data presented in the WALIS database? In record ID3832 (arbitrarily selected) the indicator is 'marine terrace' (sensu Rovere, I guess), the coral used for dating (Porites panamensis) was found in 3.1 m elevation (Table S1; no uncertainty), the shoreline angle is at 8.7±1.6 m (this is a 18% error; the elevation measurement technique is given as 'not reported'), RWL is -0.03 m and IR is 1.06 m and, logically, WALIS calculates the sea level to have been at 8.73±1.68 m.

Well, you cannot really calculate a paleo-sea level for the last interglacial period (MIS 5e) (as you have done above) anywhere on the Pacific Coast of North America because you cannot assume tectonic stability anywhere. I tried to emphasize this throughout the course of the manuscript. Most parts of the coast are uplifting (based on observations of multiple terraces at a range of elevations) and to calculate a paleo-sea level for MIS 5e, you would have to know the uplift rate. How would you do that? In most places here and elsewhere, uplift rates are calculated MIS 5e terrace elevations (on the uplifting coast) and an assumed paleo-sea level from distant, tectonically stable coastlines. Otherwise, you are in the middle of an exercise in circular reasoning.

According to the IUCN database Porites panamensis occurs on coral reef communities growing on rocky substrates, at depth ranging 0 - 36 m. Following Hallmann et al. who followed Hibbert et al. 2016, 2018, this database (together with OBIS) is regarded as being the standard for coral-based SLIPs in WALIS – am I wrong? Daniel Muhs indicates 0 - 10 m for all corals in the study area following Glynn and Ault (2000) who focused on coral life history and population dynamics since the closure of the central-American seaway. There is no explanation as to how one of the key parameter in WALIS, that is the RWL, was inferred or calculated and it looks as if the tidal range, albeit minor, was not taken into consideration at all.

With all due respect to Hibbert et al. (2016, 2018), both excellent papers, I suspect that the authors themselves have not done any depth measurements of *Porites panamensis* along the Pacific Coast of North America. Thus, I have gone with the depth range given by Peter W. Glynn, who is probably one of the leading field-based authorities on eastern Pacific corals. He has been studying corals in this region for 50 years. If you look at Glynn and Ault's (2000) paper that I referenced,

their information on corals in this region was taken from many observations, over many years, by many researchers, and they indicate (see caption for their Figure 2) that the maximum shelf depth where corals (including *P. panamensis*) mainly occur in both the Gulf of California and mainland Mexico is about 10 meters. Recent collections of this species by marine biologists have confirmed this general depth range (see Zapata & Lozano-Cortés, 2015; *Marine Biodiversity Records* 8, 1-4; Cabral-Tena et al., 2013, *Marine Ecology Progress Series* 476, 1-8). This is also consistent with what Verrill described as its depth when he first identified and described this species (from Baja California) in 1870 (Verrill, 1870, *American Journal of Science*). Thus, I regard Glynn and Ault's (2000) statement as authoritative.

No doubt, ocean currents, ENSO cycles, the virtual absence of extended rocky shelfs and the geological history of the north-central American coast, all together control the shape of marine terraces, reef assemblages, reef construction, growth and shape. I feel that 'marine terrace' does not describe the sea-level indicator(s) that occur on the north-central American coast.

Well, it would be hard to disagree with the first sentence here that all those variables influence marine terraces and reefs on the Pacific Coast of North America.

As for the second sentence, with regard to the term "marine terrace," I guess we just have to agree to disagree. I think that "marine terrace," a term that has been in common use around the world, starting in the 19th century and continuing into the 20th and 21st centuries, is well-established and is understood by geomorphologists.

Lastly, I feel the paper would benefit if Figs 3, 18, 19, 21, 28, 36a include a key and/or a scale and if standards for numbers are followed: value and corresponding uncertainty must have the same number of digits.

Why would Figure 3 need a "key"? Everything is pointed to in the figure itself (with arrows) or in the caption text. Same goes for the other figures noted…you just have to look closely, as some of these are within the boundaries of the map itself (for example, on the map of San Nicolas Island).

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