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Biogeosciences
Discussions

Interactive comment on "Baseline for ostracod-based northwestern Pacific and Indo-Pacific shallow-marine paleoenvironmental reconstructions: ecological modeling of species distributions" *by* Yuanyuan Hong et al.

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Response to Manuscript Reviewers' Comments

Title: Baseline for ostracod-based northwestern Pacific and Indo-Pacific shallow-marine paleoenvironmental reconstructions: ecological modeling of species distributions

Dear editor and reviewer, T. M. Cronin

Thank you all for your valuable comments on my manuscript. Please find the relevant excerpts from your report reproduced below, alongside their respective responses. Yours sincerely,

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1. The results section however is awfully descriptive and redundant, each paragraph starting the same way: Relative abundance of SPECIES X was correlated only with ENVIRONMENTAL: : :. These data is given in the tables. So emphasize in discussions the key species of most utility in east Asia. The data in tables are fine, but I think the authors have to discuss the most obvious and useful species as indicators of natural [T, S DO] and human [toxics, metals] chemical and physical factors. Not just plot and chart all the data. A little variability in writing style would help too.

Thanks for pointing this out! To improve descriptive and redundant impression, we divided the discussion section into sub-sections of (a) Widespread Group, (b) Temperate Group, (c) Subtropical Group, (d) Tropical Group, and (e) Globally Distributed Group. We also revised fig 7 (now it's fig. 4) accordingly. We also add some variation to our writing style. We already selected potentially important species for this study and so would like to keep mentioning all the species, as follows:

The comprehensive ostracod dataset for the 52 sites and the environmental variables enabled us to elucidate distribution patterns of common ostracod taxa and their related environmental factor(s). We identified 151 species belonging to 76 genera (Supplement A). Among them, 18 common taxa (mainly species, a few genera) of Pistocythereis bradyi, Bicornucythere bisanensis s.l., Nipponocythere bicarinata, Spinileberis quadriaculeata, Phlyctocythere japonica, Loxoconcha epeterseni, Sinocytheridea impressa, Neomonoceratina delicata, Keijella kloempritensis, Neosinocythere elongata, Stigmatocythere roesmani, Hemicytheridea reticulata Loxoconcha malayensis, Alocopocythere goujoni, Hemikrithe orientalis, Propontocypris spp., Neonesidea spp.

and Xestoleberis spp. (Supplement B) were used for regression modelling, and their relative abundances (to the total ostracod abundance in a sample) show a significant relation with environmental parameters. The best three regression models are presented in Table 2 and the model-averaged parameter estimates in Table 3. A small percentage of specimens of phytal genera (e.g., Xestoleberis spp., Neonesidea spp.) were contained in each sample, which are basically allochthonous specimens in bottom sediments transported from surrounding phytal environments. The value of allochthonous species to environmental interpretation is limited, however most ostracod specimens in each sample are composed of benthic, muddy sediment dwellers which are considered autochthonous. Ostracods were divided into four groups based on their geographic distributions, including Widespread Group; Temperate Group; Subtropical Group; and Tropical Group; and Globally distributed Group (Fig. 4).

a. Widespread Group

Only one species Pistocythereis bradyi constitutes Widespread Group. Pistocythereis bradyi is widely distributed throughout the marginal marine environments of Japan, the East and South China Seas, and the Indo-Pacific (Fig. 4). Relative abundance of P. bradyi was highly correlated with salinity (positive), water depth (negative) and Pb (negative) (Tables 2 and 3). This indicates the species prefers relatively shallow environments with high salinity (Figs. 2 and 5). In the Pearl River Delta and shallow South China Sea (Fig. 4), P. bradyi is dominant along the inner continental shelf at water depths <100 m (mostly common between 10–50 m), and at salinities from 30–40 (Li, 1985; Zhao & Wang, 1990; Zhao et al., 1986). Pistocythereis bradyi is a typical middle muddy bay species in Japan (Irizuki et al., 2006; Yasuhara & Irizuki, 2001; Yasuhara & Seto, 2006), and known from open bays such as Gamagyang Bay in Korea (Abe, 1988) and Malacca Strait (Whatley & Zhao, 1988b). In these studies, P. bradyi prefers relatively high salinity and deeper water in the inner continental shelf (Tables 2 and 3). Our data agree as to the preference for high salinity, but inconsistent with the literature regarding shallower water depths. Salinity may be more important than

depth, but the restricted depth range of our sites ($\leq$35 m) may also be a reason for this inconsistency. Our results indicate that P. bradyi is sensitive to metal pollution.

b. Temperate Group

Five species including Bicornucythere bisanensis s.l., Nipponocythere bicarinata, Spinileberis quadriaculeata, Phlyctocythere japonica and Loxoconcha epeterseni are distributed from Japan-Russian Coast to South China Sea. Bicornucythere bisanensis s.l. is very common in most samples, the relative abundance of which was significantly correlated with water depth (negative) (Tables 2 and 3) and this species prefers shallower environments (Figs. 2 and 5). In Chinese and Japanese coastal areas, B. bisanensis s.l. is abundant in brackish water (salinity: 20–30) at depths less than 10 m (Ikeya & Shiozaki, 1993; Irizuki et al., 2006; Zhao et al., 1986). Our results confirm this preference for shallow depths. In Japan, Bicornucythere bisanensis is tolerant of anthropogenic impacts, especially eutrophication and the resulting bottom water hypoxia (Irizuki et al., 2003; Irizuki et al., 2011; Irizuki et al., 2015a; Irizuki et al., 2018; Yasuhara et al., 2003; Yasuhara et al., 2007; Yasuhara et al., 2012a). We did not see a significant relation between relative abundance and metal concentration, productivity, or dissolved oxygen. Possibly, the more dominant presence of S. impressa and N. delicata, that are neither dominant or distributed throughout most of Japan, could explain this difference. These species may have a higher tolerance than B. bisanensis s.l.. Another explanation may be that different morphotypes have different ecological preferences (Abe, 1988), and only Form A is known to be tolerant to eutrophication and bottom-water oxygen depletion (Irizuki et al., 2011; Irizuki et al., 2015a; Irizuki et al., 2018; Yasuhara & Yamazaki, 2005; Yasuhara et al., 2007). Form A is less abundant in Hong Kong, and due to the difficulty of juvenile identification, we did not divide B. bisanensis into morphotypes. Bicornucythere bisanensis s.l. is widely distributed throughout marginal marine environments around Japan, Russia (Sea of Japan coast), and the East and South China Seas (Fig. 4). Relative abundance of N. bicarinata correlated with productivity (negative) (Tables 2 and 3). This is a typical middle bay species in Japan (Irizuki

et al., 2006), abundant on muddy substrates at water depths >10 m (Yasuhara & Seto, 2006; Yasuhara et al., 2005). We found N. bicarinata to be sensitive to eutrophication, prefering lower productivity (Figs 2 and 5). This species is know from marginal marine environments around Japan and the East and South China Seas (Fig. 4). Relative abundance of S. quadriaculeata correlated to productivity (positive), and turbidity (negative) (Tables 2 and 3). This is a typical inner muddy bay species in Japan (Irizuki et al., 2006), which prefers silty substrates in brackish waters, at salinities from 20–30, and water depths of 2–7 m (Ikeya and Shiozaki, 1993). This study shows a preference for waters with higher productivity but relatively low turbidity (Tables 2 and 3), so that the species is abundant in Tolo Harbour (higher productivity, lower turbidity) but not in Deep Bay (higher turbidity) (Figs. 2 and 5). Spinileberis quadriaculeata is not tolerant to seasonal anoxia or oxygen depletion (0–1 mg/L) in Uranouchi Bay, Japan (Irizuki et al., 2008), but we do not find a significant correlation with dissolved oxygen content, probably due to the relatively high bottom-water oxygen content (2.96–6.84 mg/L) in Hong Kong (Fig. 2; Supplement B). Spinileberis quadriaculeata is widely distributed in marginal marine environments around Japan, Russia (Sea of Japan coast), and the East and South China Seas (Fig. 4). Relative abundance of P. japonica correlated with water depth (positive) (Tables 2 and 3). This species is known from relatively deeper waters (>40 m) in the East China Sea (Ishizaki, 1981; Wang et al., 1988). At our sites, it has its greatest abundance at the deeper southern sites (Fig. 5). Phlyctocythere japonica is distributed around Japan (Yasuhara et al., 2002) and the East and South China Seas (Fig. 4). Similarly to P. japonica, relative abundance of L. epeterseni correlated with water depth (positive), and turbidity (negative) (Tables 2 and 3). It occurs in the southern and eastern, deeper and less turbid regions of Hong Kong waters, but the trend is not very clear (Figs 2 and 5). This species is also known from the deeper parts of Osaka Bay (Yasuhara & Irizuki, 2001) and marginal marine environments around Japan (Ishizaki, 1968), the East China Sea (Yang et al., 1982), and the South China Sea (Cao, 1998) (Fig. 4). This species is reported as Loxoconcha modesta in Hou & Gou (2007), and also has been misidentified as Loxoconcha viva and Loxoconcha

sinensis (Hou & Gou, 2007). Ishizaki (1968) described Loxoconcha laeta and Loxoconcha modesta, but these are the females and males of the same species (Ikeya et al., 2003). Ishizaki (1981) gave the new species names Loxoconcha epeterseni and Loxoconcha tosamodesta for Loxoconcha laeta and Loxoconcha modesta, respectively, because these names were junior homonyms. Since Loxoconcha laeta (= epeterseni) appears earlier than Loxoconcha modesta (=tosamodesta) in the original description (Ishizaki, 1968), we use the name Loxoconcha epeterseni for this species (e.g., see Ikeya et al., 2003).

c. Subtropical Group

Six species including Sinocytheridea impressa, Neomonoceratina delicata, Keijella kloempritensis, Neosinocythere elongata, Stigmatocythere roesmani and Hemicytheridea reticulata are reported from the East China Sea to Indo-Pacific area. Sinocytheridea impressa [=Sinocytheridea latiovata; see Whatley and Zhao (1988a)] is the most dominant species, the relative abundance of which was significantly correlated with salinity (negative), dissolved oxygen (negative), mud content (positive) and productivity (positive) (Tables 2 and 3). This species is noticeably dominant in areas characterized by a muddy bottom including northern Mirs Bay, Port Shelter and coastal Southern Waters (Fig. 5). It is also abundant in Tolo Harbour, an area known for its summer hypoxia and eutrophication (Hu et al., 2001; Sin & Chau, 1992). These results are consistent with previous studies indicating that S. impressa is dominant in low salinity, nutrient-rich and turbid estuaries (Irizuki et al., 2005; Tanaka et al., 2011), but we did not see a significant relation with turbidity (Tables 2 and 3). Sinocytheridea impressa is known as a euryhaline species widely distributed throughout the East and South China Seas [abundant in water depths of <20 m; Whatley and Zhao (1988a)], and the Indo-Pacific (Fig. 4). Neomonoceratina delicata (=Neomonoceratina crispata; see Hou & Gou, 2007) is very common in most of the samples, and the relative abundance significantly correlates with Zn (positive), salinity (positive) and turbidity (positive) (Tables 2 and 3). Neomonoceratina delicata is a nearshore species, abundant at depths

less than 30 m, at relatively high salinities (>30; Zhao and Wang, 1988). It prefers the higher salinity waters in Hong Kong (Figs. 2 and 5; Tables 2 and 3) and in view of its positive correlation with Zn and turbidity, is likely tolerant to human-induced environmental stress such as pollution and eutrophication. This species is widely known from nearshore and estuarine environments in the East and South China Seas, and the Indo-Pacific (Fig. 4). The relative abundance of K. kloempritensis correlated only with water depth (positive) (Fig. 6; Tables 2 and 3). Widely known from the tropical Indo-Pacific region, K. kloempritensis is abundant along the inner continental shelf of the South and East China Seas (Fig. 4), at water depths ranging from 20–50 m and salinity close to normal marine (Zhao & Wang, 1990). Our modelling results are consistent with this, showing a preference for the relatively deeper waters in our study (Tables 2 and 3). Thus, this species is probably useful for reconstructing past sea-level changes in the broad tropical and subtropical Indo-Pacific and northwestern Pacific regions as a deeper water indicator. Relative abundance of N. elongata correlated only with turbidity (positive) (Tables 2 and 3). This species occurs along the entire coast of China (Fig. 4) in marginal marine, especially estuarine environments shallower than 20 m (Dong et al., 2012; Hou & Gou, 2007; Liu et al., 2013; Liu et al., 2017; Zhao & Whatley, 1993) (Fig. 4). Known from the Indo-Pacific region, our modeling results and previous studies indicate consistently that N. elongata prefers shallow, turbid waters like Deep Bay and the Pearl River Estuary (Figs 2 and 6). The relative abundance of both S. roesmani and H. reticulata correlated with Pb (negative) (Tables 2 and 3), thus they are sensitive to metal pollution (but note the significant autocorrelation with the modeling result of S. roesmani) and absent in areas with high metal concentrations, e.g., Tolo and Victoria Harbours (Fig. 3, 6). Relative abundance of H. reticulata also correlated with water depth (negative) (Tables 2 and 3). This species is abundant in Tolo Harbour and the inner part of Mirs Bay (Fig. 6), at shallow depths, and is also consistently found in very shallow waters from the Indo-Pacific (Zhao & Whatley, 1989). Their metal-pollution sensitivity is contradictory because they occur in Tolo and Victora Harbours, both polluted regions of Hong Kong, and further research is needed to better

understand these results (Figs 2 and 6). They occur in the East and South China Seas and the Indo-Pacific region (Fig. 4).

d. Tropical Group

Three species including Loxoconcha malayensis, Alocopocythere goujoni and Hemikrithe orientalis are distributed from the South China Sea to the Indo-Pacific. Relative abundance of L. malayensis correlated with dissolved oxygen (negative) and mud content (negative) (Tables 2 and 3). It is a typical tropical species known from the Indo-Pacific and the South China Sea (Fig. 4). We did not find a correlation with temperature, likely due to the small range of variation of bottom water temperatures in Hong Kong (winter temperature: 19.10–21.49°C). This species prefers coarse sediments and is resistant to low oxygen content (Table 2 and 3), as seen by its abundance in Victoria Harbour (Figs. 2 and 6). Relative abundance of both A. goujoni and H. orientalis correlated with natural factors only. Alocopocythere goujoni correlated with salinity (positive) (Tables 2 and 3) and occurs not only in Mirs Bay where the salinity is higher, but also in Deep Bay and North Western Waters where the salinity is lower than in other areas (Figs 2 and 6). The Deep Bay and North Western Waters are shallow and have relatively low oxygen content. The modeling result of this species shows a marginally insignificant but negative relationship to oxygen content and water depth with moderately high relative importance (Table 3). We explain this inconsistency by considering their preference for higher salinity and shallow water depths, and also their resistance to low oxygen conditions, but further research is needed to know their autoecology with better confidence. Relative abundance of H. orientalis correlated with water depth (positive) (Tables 2 and 3; but note the significant autocorrelation with the modeling result of this genus), and it is more abundant in deeper waters including southern Mirs Bay (Fig. 6). It is known from depths of 20–50 m in the South China Sea (Zhao & Wang, 1988a), and reported from tropical Indo-Pacific marginal marine environments (Fig. 4). Our regression modeling consistently shows a positive relationship between relative abundance and winter temperatures, with moderately high relative importance,

although the correlation is marginally insignificant (Table 3).

e. Globally Distributed Group

Propontocypris is known as a cosmopolitan genus. The relative abundance of Propontocypris spp. significantly correlated with productivity (negative) (Tables 2 and 3). This negative correlation with productivity (but note a significant autocorrelation with the modeling result of this genus) indicates that the genus prefers less eutrophic waters (Fig. 6). Propontocypris is a good swimmer (Maddocks, 1969), and thus may have an advantage in obtaining food in relatively food-limited environments. Phytal genera including Neonesidea spp. and Xestoleberis spp. have global distribution and are correlated with various environmental factors. The relative abundance of Neonesidea spp. correlated with dissolved oxygen (positive), as expected for a phytal species (Smith & Kamiya, 2002; Yamada, 2007) (Table 2 and 3; Fig 7). Similarly, phytal (Irizuki et al., 2008; Sato & Kamiya, 2007; Yasuhara et al., 2002) Xestoleberis spp. correlated with dissolved oxygen (positive), turbidity (negative) and mud content (negative) (Table 2 and 3; Fig. 7). This taxon's habitat preference including clear water, coarse sediment, and high oxygen content are reflected in our modeling. As mentioned above, the value of allochthonous phytal species to environmental interpretation is limited, but they broadly reflect adjacent phytal environments.

Regarding the most obvious and important species, we already mentioned S impressa and N delicata in the abstract.

2. Tropical not tropic?

Thanks! Now we revised the MS and consistently use “tropical” as an adjective and “tropics” as a noun.

3. Some might argue 150 microns and larger misses some smaller species.

As discussed in the method section, most specimens smaller than 150 um will be early juveniles that are rarely preserved or difficult to identify. More datailes are discussed

in Yasuhara et al 2017 Journal of Biogeography. So, we revised the relevant sentence in the method section as follow: "The residue was dry-sieved over a 150 μm mesh sieve, and ostracod specimens larger than 150 μm were picked; smaller individuals are mostly early instar juveniles that are often not preserved (because their shells are usually thin and delicate) or difficult to identify (see Yasuhara et al., 2017 for more details)."

4. I wonder why most specimens were dead shells and living animals were so scarce?

We don't know why (perhaps low population density or loss of living specimens during sampling or both). But it's quite common in grab sample based studies. However, dead shells eventually become fossils, so usage of mostly dead shells for obtaining autoecological information for paleoenvironmental application is reasonable.

5. Line 289. Why if K. kloempritensis lives in deeper water is it useful for sea level reconstruction? Species that live at or mean SL are best.

We agree that species living at mean SL are very useful, but our samples don't cover intertidal environments. K. kloempritensis is useful for sea level reconstructions at least in qualitative sense, because it could be an indicator for deeper water and tropical species rarely have such detailed autoecological information. The presence or higher relative abundance indicates higher relative sea-level.

6. Figure 7 could be re-designed to show the distributions better, for example, in shallow water regions.

We revised Fig. 7 to address your comment 1 above. We rearranged the order of species according to their geographic distribution groups. We also vertically compressed the map a bit for better visual. But please note than primary aim of this fig is to visualize large scale geographic distributions approximately, and it's out of the scope to show detailed or fine scale distributions.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-405/bg-2018-405-AC4-supplement.pdf

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-405, 2018.

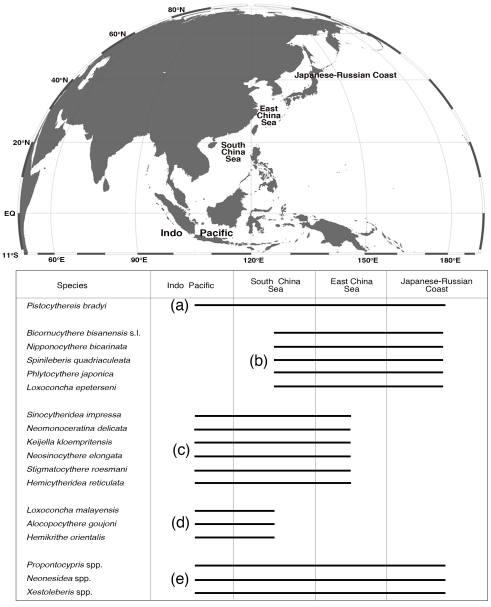

Fig. 1. Fig. 4