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1 *Architectonica karsteni* Rutsch, 1934 (Gastropoda: Architectonicidae) in seamounts of
2 the Nazca-Desventuradas Marine Park: First record in Chilean waters since the
3 Miocene.

4

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29 ABSTRACT

30 The presence of Architectonicidae in Chile was previously recorded only from fossil
31 material of eight species present during the Lower Miocene, when *Architectonica*
32 *karsteni* had a geographic range that extended from Costa Rica to central Chile (34°S).
33 No evidence of the presence of the family in Chile after the Lower Miocene have been
34 reported. As part of this study, we report the discovery of *A. karsteni* at four seamounts at
35 ~200 m water depth in the recently created Nazca-Desventuradas Marine Park, located
36 ~900 km west of continental Chile. Morphological identification was based on
37 protoconch diameter, coloration patterns, and teleoconch sculpture. We also provide
38 sequence data for portions of the mitochondrial *COI* and *16S* rRNA genes to contribute
39 to data available for future population-level and phylogenetic analyses of this poorly
40 known group. Insight on the habitat of the species, based on underwater imagery is also
41 provided. This new record extends the geographic distribution of *A. karsteni* ~20°
42 southward from its current recorded range (i.e., Baja California to Perú). The finding of
43 this species highlights the relevance of gaining knowledge of the fauna inhabiting these
44 seamounts to inform conservation efforts of these relatively pristine habitats.

45

46 **Keywords:** Benthos, Mesophotic zone, Biogeography, Southeast Pacific Ocean, Sundial
47 shell, *COI*, *16S* rRNA.

48 INTRODUCTION

49 Architectonicidae (commonly called “sundials”) are a family of subtropical to tropical
50 marine gastropods (Bieler, 1984). Their shell shape typically ranges from trochoidal to
51 discoidal with a basal-centered umbilicus but occasionally it is planispiral with disjunct
52 whorls. They are characterized by a hyperstrophic protoconch with the apex projected
53 into the teleoconch umbilicus (Bieler, 1993). Architectonicids have planktotrophic larvae

54 with larval durations that range from several weeks to several months (Robertson, 1967),
55 allowing the larvae to be displaced over large distances (sometimes 1000s of km) by
56 currents and therefore enabling them to maintain the wide geographical distributions
57 reported for some species of this family (Bieler and Petit, 2005). For instance, several
58 species, such as *Architectonica perspectiva* (Linnaeus, 1758) and *Heliacus variegatus*
59 (Gmelin, 1791), have extremely wide ranges extending from the African Indian Ocean
60 coast to the islands of the Central Pacific (Bieler, 1993). A few of them, including
61 *Heliacus trochoides* (Gmelin, 1791) and *Psilaxis radiatus* (Röding, 1798), are known to
62 extend to the eastern Pacific coast from the Indo-West and Central Pacific (Robertson,
63 1976, 1979). The distribution of architectonicid species may be limited by the
64 temperature requirements of their cnidarian prey more than to their own tolerance (Bieler,
65 1993) based on architectonicid larvae having been collected at water temperatures as low
66 as 13.5 °C (Scheltema, 1971) and adults collected alive in deep waters at temperatures as
67 low as 2.4 °C (Bieler, 1993). Changes in oceanographic conditions, current patterns,
68 and/or availability of prey may therefore have caused many species to have suffered
69 reductions in their range of geographical distribution and to become extinct at high
70 latitudes during the Miocene (Frassinetti and Covacevich, 1981; Nielsen and Frassinetti,
71 2007) and. For example, *Heliacus (Heliacus) fallaciosus* (Tiberi 1872) (= *Solarium*
72 *obtusum* Bronn 1831) is known as a Neogene fossil from the North Sea (Janse and
73 Janssen, 1983) but has no extant representatives in that ocean (Melone and Taviani,
74 1984).

75 Such extinctions and reductions in geographic ranges have resulted in only two extant
76 species of Architectonicidae having a known range that extends into Chilean waters.
77 However, these species, *Heliacus implexus* (Mighels, 1845) and *Spirolaxis cornuarietis*
78 (Bieler, 1993), are only known from Rapa Nui (Easter Island), which is ~3700 km west

79 of continental Chile (Rehder, 1980; Bieler, 1993; Osorio, 2018). Nevertheless, samples
80 collected from the Navidad Formation (~34°S, Figure 1), Ranquil Formation (~ 36.6°S)
81 and Lemo Island (~44.64°S) reveal that at least eight species of the family were present
82 in Chile during the Lower Miocene (Frassinetti and Covacevich, 1981; Nielsen and
83 Frassinetti, 2007). These species include: *Architectonica karsteni*, *Intitectonica inti*
84 (Frassinetti and Covacevich, 1982), *Discotectonica navidensis* Frassinetti and
85 Covacevich, 1982), *Heliacus (Torinista) taverai* Frassinetti and Covacevich, 1981,
86 *Heliacus (Torinista) bahamondei* Frassinetti and Covacevich, 1981, *Heliacus (Torinista)*
87 *chonos* Nielsen and Frassinetti, 2007, and *Solatisonax bieleri* Nielsen and Frassinetti,
88 2007.

89 *Architectonica karsteni* was described by Rutsch (1934) from the Miocene Cantaure
90 Formation of northern Venezuela as a subspecies of *Architectonica nobilis* Röding, 1798.
91 It was first reported for Chile as part of the fossil record of the Miocene by Frassinetti
92 and Covacevich (1981). Additional records revealed that *A. karsteni* was consistently
93 present in the Lower Miocene fossil record in Central Chile and fossil records from the
94 Miocene and Miocene-Pliocene boundary in Mexico (~16°N) (Böse , 1906), Venezuela
95 and Grenadine Islands (DeVries, 1985; Nielsen and Frassinetti, 2007) (Figure 1). These
96 records suggest that the geographic range of *A. karsteni* during the Miocene spanned the
97 east Pacific and even the Caribbean Sea coasts, a wider longitudinal distribution relative
98 to its current distribution. The present range of the species extends from Baja California
99 (~32° N) to Perú (~5° S) (Figure 1) at 50 to 190 m depth on a variety of substrata (e.g.,
100 mud, fine sand, shells, gravel) (DeVries, 1985; Bieler, 1993). No records of living *A.*
101 *karsteni* have been reported so far for the Pacific Ocean south of 5° S, the Caribbean Sea
102 or the Atlantic (Bieler, 1993).

103 In this paper, we report the presence of *A. karsteni* at four seamounts near the junction of
104 the Salas y Gómez and Nazca Ridges (~25°S, 82°W) within the newly created Nazca-
105 Desventuradas Marine Park (NDMP), Chile (Figure 1). In addition, we provide sequence
106 data for the barcode regions of the mitochondrial (mt) *16S* ribosomal RNA (*rrnaL*) and
107 cytochrome oxidase I (*COI*) genes of *A. karsteni* and present them in a phylogenetic
108 context with the only four Architectonicidae species with *COI* or *16S* barcode data:
109 *Architectonica perspectiva* (*COI*, *16S*), *A. maxima* (*16S*), *Philippia lutea* (*COI*), and
110 *Psilaxis radiatus* (*16S*). A description of the habitat of the species based on underwater
111 imagery is also provided.

112

113 MATERIALS AND METHODS

114 **Study region**

115 From October to November 2016, a multidisciplinary oceanographic cruise (CIMAR 22
116 “Oceanic Islands”) was carried out onboard the research vessel *AGS61 Cabo de Hornos*.
117 The aim of the cruise was to study the benthic habitats and fauna of unexplored seamounts
118 of the Juan Fernández and Desventuradas Ecoregion (Spalding et al., 2007). The northern
119 extent of this ecoregion falls within the latitudinal range of *A. karsteni* and includes the
120 islands of the Desventuradas and the surrounding seamounts, which are part of the 144
121 seamounts of the Nazca and Salas y Gómez Ridges. The Salas y Gómez Ridge is a long
122 and narrow seamount chain stretching from the East Pacific Rise (west of Easter Island
123 in the Easter Island Ecoregion) at ~27°01′ S, 111°00′ W to just west of the Desventuradas
124 Islands at ~25° 27′ S, 81°43′ W, where it merges with the Nazca Ridge, which stretches
125 in a northeastern direction to ~17°43′ S ,78°07′ W (Parin et al., 1997; Galvez Larach,
126 2009). Of these seamounts, 21 are in the Chilean exclusive economic zone (EEZ) around
127 the Desventuradas (Yáñez et al., 2009). Prior to this study, benthic habitats of the

128 seamounts within the EEZ surrounding the Desventuradas had not been explored. Some
129 of the adjacent seamounts at the junction of these two ridges were surveyed in the 1970s
130 and 1980s (Parin et al., 1997; Mironov et al., 2006). These surveys revealed that these
131 seamounts are characterized by a highly endemic fauna with well-expressed Indo-West
132 Pacific affinities, with only the easternmost seamounts having some species with
133 affinities to the fauna of the adjacent continental coast of South America (Parin, 1991).

134 **Material collection**

135 Within the NDMP, the slopes of San Ambrosio and San Felix islands (i.e., Desventuradas
136 Islands) and summits of six seamounts were surveyed using a remotely operated vehicle
137 (ROV) and a modified Agassiz trawl. Unless weather or sea conditions precluded the use
138 of one of the survey methods, the protocol for the benthic survey consisted of a visual
139 survey of the study site using an ROV (Commander MK2; Mariscope Meerestechnik,
140 Kiel, Germany) equipped with a HD Camcorder (Panasonic SD 909) and laser pointers
141 (10 cm apart) followed by sampling with the Agassiz trawl. The latter consisted of a metal
142 frame with a mouth of 1.5 m × 0.5 m (width × height) fitted with a net of 12 mm mesh at
143 the cod end, operated in 10 min hauls (bottom contact) at ~2 knots. Collected specimens
144 were preserved in 100% ethanol and voucher specimens deposited in the biological
145 collections of the Universidad Católica del Norte (SCBUCN). Sample collection was
146 performed under permission Res. Ext N°41/2016 from SERNAPESCA (Chile) to
147 Universidad Católica del Norte. This resolution authorizes us to collect species
148 throughout the NDMP area until October 2020.

149 **Taxonomic Identification**

150 Identification of the seven empty shells and three living specimens of architectonicids
151 (Table 1) was made according to Bieler (1993). The teleoconch sculpture and protoconch
152 diameter of one living specimen (ID number SCBUCN 6928a) was examined with a

153 Hitachi SU3500 scanning electron microscope (SEM) at the Microscopy Laboratory of
154 the Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile. The
155 shell was dried in a laboratory drying oven at 65°C for 24 h and mounted on bronze stubs
156 without metal coating.

157 **Molecular data**

158 Whole genomic DNA was isolated from the muscle tissue of the foot of a specimen (ID
159 number SCBUCN 6950) with the GeneJET Genomic DNA Purification Kit
160 (ThermoFisher Scientific Waltham, MA) per manufacture's protocol and submitted to
161 Biopolymers Facility at Harvard Medical School for library preparation and next-
162 generation sequencing (NextSeq 500). Trimmed reads (Trimmomatic-0.32, Bolger et al.,
163 2014) were assembled de novo with SPAdes (Bankevich et al., 2012) on the University
164 of New Hampshire Bioinformatics Core facility RON server. The resulting SPAdes
165 contig consensus sequences were blasted (Blastn) against the reference mitochondrial
166 genomes in GenBank to identify which of the contigs corresponded to the mitochondrial
167 genome of *A. karsteni*. After circularizing and editing overlapping ends of the identified
168 SPAdes contig in Geneious R11.1.5 (Kearse et al., 2012), trimmed reads (BBduk v.
169 37.25) were mapped to this reference sequence in Geneious and reviewed manually for
170 quality control (e.g., to confirm read coverage was sufficient, ≥ 10). The resulting
171 consensus sequence was used to annotate the mitochondrial genome based on annotations
172 identified by MITOS (Bernt et al., 2013) with gene boundaries manually adjusted based
173 on alignment of individual genes with the gastropod *Siphonaria gigas* reference
174 mitochondrial genome (NC_016188).

175 The complete *COI* and *16S* rRNA sequences were uploaded to GenBank (MN270389
176 and MN270388, respectively) and aligned separately with default MUSCLE (Edgar,
177 2004) parameters to all Architectonicidae sequences available in GenBank. Because only

178 two Architectonicidae species, *Architectonica perspectiva* (FJ917269) and *Philippia*
179 *lutea* (AY296843), had *COI* sequences available in GenBank, we also included four
180 species belonging to two superfamilies assumed closest to Architectonicoidea (Dinapoli
181 and Klussmann-Kolb, 2010): Omalogyroidea (*Omalogyra fusca* - FJ917272, *Omalogyra*
182 sp. - FJ917273) and Valvatoidea (*Valvata piscinalis* - FJ917267, *Cornirostra pellucida* -
183 FJ917282). For the alignment of *16S* rRNA sequences, 50 haplotypes of
184 Architectonicidae sp. (MH557974 to MH558023) were available in addition to one
185 sequence each from *A. perspectiva* (FJ917251), *A. maxima* (KP252986) and *Psilaxis*
186 *radiatus* (AY081999). Prior to reconstruction of the phylogeny, alignments were trimmed
187 to the shortest region with sequence data for all individuals. Because the available *COI*
188 sequence for *P. lutea* (623 bp) is from a different section of the gene than *A. perspectiva*
189 (577 bp) and the four other species used to construct the phylogeny, there was only 322
190 bp of overlap for all sequences. Therefore, *P. lutea* was included in alignments to
191 determine pairwise divergences compared with *A. karsteni*, but it was removed from the
192 phylogenetic tree construction. The resulting alignments were used to construct the
193 respective phylogenetic trees with PhyML 3.0 (Guindon et al., 2010) Geneious plugin,
194 with the following settings: bootstrap replicates = 1000, optimize =
195 Topology/length/rates, Topology search = NNI, nucleotide model substitution = GTR.
196 Significant bootstrap values (>90) are reported at the nodes.

197

198 RESULTS

199 Samples and habitat description

200 A total of seven empty shells and three living *Architectonica karsteni* specimens were
201 collected at four stations within the NDMP (Table 1); however, live specimens were only
202 collected from seamount SF.5 (Figure 1). The smallest shell measured 14.3 mm in

203 diameter and the two largest measured 28.4 mm in diameter. Although 4 to 15 other
204 mollusk taxa were found at each of the four collection sites, species that co-occurred with
205 *A. karsteni* at three or more sites were *Atrimitra isolata* (Sellanes and Salisbury, 2019)
206 (Mitridae) and *Chryseofusus kazdailisi* (Fraussen and Hadorn, 2000) (Fascioliariidae),
207 which were collected at SF.5, SF.6 and SF.9 seamounts; as well as empty shells of the
208 bivalve *Tucetona kauaia* (Dall, Bartsch and Rehder, 1938) (Glycymerididae), which were
209 collected at SF.5, SF.9 and S21 seamounts. Of the four seamounts in which *A. karsteni*
210 was collected, three (SF.6, SF.9 and S21) were also surveyed by ROV. Benthic habitats
211 at SF.6 and SF.9 were dominated by coarse sand and the presence of maërl-rhodoliths,
212 scattered rocky outcrops were also spotted at these sites (Figures 2-5). The bottom at S21
213 was dominated by finer sand (Figures 6-7). Wind and current conditions prevented the
214 deployment of the ROV at SF.5, where the live specimens were collected.

215 **Shell morphology**

216 Shells of live collected specimens have the characteristic yellowish red marbled color
217 pattern of the species (Figures 8-9) (Bieler, 1993). Subsutural and peripheral ribs are
218 whitish with more or less irregular brown blotches (about 10-16 on 4th whorl of upper
219 peripheral rib, each 1-2 nodules wide); mid ribs are light-brown or bluish-grey, they are
220 more or less weakly mottled with brown; the basal field is light-brown or bluish-grey with
221 5-6 dotted or more or less solid spiral lines (marking the reduced spiral ribs of the basal
222 field), wider towards the umbilicus. The umbilical crenae are whitish with a light- to dark-
223 brown pattern. In contrast, most of the empty shells showed a uniform greenish yellow
224 color due to loss of color and different degrees of erosion, although all of them were
225 distinguishable as *A. karsteni* because the distinctive architecture of the shell was
226 sufficiently conserved for species assignment.

227 Shell morphology of all samples were consistent with the description published by Bieler
228 (1993) . The protoconch of only one specimen was measured because the protoconch of
229 most of the other specimens showed a high degree of erosion, precluding accurate
230 measurements. Even in the photographed specimen, it was difficult to distinguish the
231 boundary between the end of the protoconch, the “stage of arrested growth” and the
232 beginning of the teleoconch (Figure 11). The protoconch of specimen SCBUCN 6928a
233 measures 943 μm (Figure 11) and is whitish to light-brown in color.

234 ***COI* and *16S* rRNA data**

235 The only sequence data available in GenBank for Architectonicidae species are *COI*, *16S*
236 and nuclear *18S* and *28S* rRNA genes for *Architectonica perspectiva*; *16S* for *A. maxima*;
237 *COI*, *28S*, and nuclear Histone 3 (*H3*), *U2* and small nuclear RNA for *Philippia lutea*,
238 *16S* for *Psilaxis radiatus* and *H3* for *Heliacus variagatus*. At the level of uncorrected
239 nucleotide substitutions, *A. karsteni* was 18.6% divergent from both *A. perspectiva* and
240 *P. lutea*. However, the amino acid sequence of *A. karsteni* was identical to that of *A.*
241 *perspectiva*, whereas these species differed from *P. lutea* by 3 amino acids (2.80%). The
242 percentage divergence based on nucleotide substitutions was 17.63% across the complete
243 573 bp alignment of *A. perspectiva* and *A. karsteni* and the translated amino acid sequence
244 differed by one (0.52%) change of Val to Ile. Divergence based on nucleotide
245 substitutions was 17.98% across the 623 bp alignment of *P. lutea* and *A. karsteni* and the
246 amino acid sequences differed by six positions (2.90%). The phylogenetic tree
247 reconstructed based on the 580 bp *COI* alignment shows *A. karsteni* sister to *A.*
248 *perspectiva* and Architectonicoidea sister to Omalogyroidea, which together are sister to
249 Valvatoidea with a strong (>98) bootstrap support (Figure 12). The 415 bp alignment and
250 phylogenetic tree based on *16S* rRNA sequence data revealed that none of the other
251 Architectonicidae spp. had the same haplotype as *A. karsteni*, which differed by at least

252 17.28% from the most similar haplotype (Architectonicidae sp.-MH557975); *A. karsteni*
253 was 19.53% divergent from *Psilaxis radiatus*, the most similar haplotype belonging to a
254 specimen assigned to species level. Because most of the GenBank sequences belong to
255 indeterminate species of Architectonicidae, little additional information can be extracted
256 from the resulting phylogenetic tree (Figure 13).

257

258 DISCUSSION

259 Information about the invertebrate benthic fauna inhabiting seamounts of the Salas y
260 Gómez and Nazca Ridges is scarce, and most of it is associated with studies carried out
261 between 1973 and 1987 (Mironov and Detinova., 1990; Parin et al., 1997). Parin et al.
262 (1997) reviewed the fauna for 22 seamounts from which they reported one species of
263 Polyplacophora, 27 species of Gastropoda (most of them of the superfamily Conoidea),
264 seven species of Bivalvia, and seven species of Cephalopoda, the latter probably pelagic.
265 No representatives of the family Architectonicidae were reported for the area in the
266 studies reviewed by these authors or any other study until now. The new records of *A.*
267 *karsteni* in the NDMP provided as part of this study not only adds a species to the
268 malacological fauna reported for the Salas y Gómez and Nazca Ridges, but also restores
269 a species to Chile that has been believed extinct from its jurisdictional waters since 23-
270 17 Ma (Nielsen and Frassinetti, 2007; Nielsen and Glodny, 2009; Finger et al., 2013).

271 The presence of *A. karsteni* in the seamounts of NDMP may result from two alternative
272 scenarios. The first is that the sampled individuals could belong to relict populations that
273 persisted in the area since the Miocene. The seamounts where the *A. karsteni* specimens
274 were collected have ages between 32 and 34 Ma (EarthRef.org, 2019) and likely hosted
275 active reefs on their summits during the Miocene, as indicated by fossil corals and
276 gastropods found on nearby seamounts (Menard, 1964; Gevorkyan et al., 1987). After

277 oceanographic changes occurred that resulted in loss of populations across their
278 geographic range, the relict populations of *A. karsteni* could have remained isolated
279 without undergoing changes in shell morphology, which would be consistent with
280 evidence suggesting that Architectonicidae of the Indo-Pacific is a slowly evolving group
281 (Bieler, 1993). Bieler based this conclusion in part on the lack of morphological
282 differences found between Indo-Pacific and Atlantic species despite the genetic flow
283 between them ceasing with the closure of the Isthmus of Panamá in the Pliocene (~3.5
284 Ma). It has been suggested that the Humboldt Current System, with its characteristic cold
285 and nutrient-rich waters, could act as a barrier, at least, separating the biota of this area
286 from the South American coast (Friedlander et al., 2016). Moreover, seamounts are also
287 known to generate particular circulation patterns (e.g., Taylor column, Taylor cone) that
288 could contribute to the retention of locally generated larvae (Rogers, 1994; 2018). All
289 these physical factors could contribute to the isolation of the local fauna, resulting in the
290 populations seamounts being repopulated with larvae generated within the nearby
291 seamount populations and under complete isolation since 23 mya (Nielsen and
292 Frassinetti, 2007). The oceanographic changes registered since the Miocene along the
293 coast may not have affected the seamounts but may have isolated the seamount
294 populations of *A. karsteni* from the continental coasts. If these isolated populations
295 continued to evolve genetically with little changes in shell morphology, *A. karsteni* found
296 on the NDMP seamounts could be a cryptic (and possibly sibling) species of populations
297 currently living on the continental shelf of the Pacific coast of Central America, as
298 documented for several sacoglossan sea slugs species (Carmona et al., 2011). The fact
299 that *A. karsteni* has not been sampled from other seamounts is not attributed to the mesh
300 size used in other studies, since gastropods species with similar or even smaller sizes have
301 been reported (e.g., *Ptychosyrinx naskensis* Sysoev and Ivanov, 1985). Neither is it likely

302 related to differences in depth of the seamounts sampled, because the depths of the
303 seamounts sampled during the CIMAR 22 (Table 1) were in the same range as previous
304 expeditions (Parin et al., 1997). Although we still cannot rule out insufficient sampling
305 effort, the absence of *A. karsteni* in other seamounts may have been due to the existence
306 of differences in the oceanographic conditions and subsurface marine currents that may
307 affect the subsistence of this species directly, or indirectly through effects on their
308 cnidarian prey.

309 In the second scenario, the sampled population could be the result of colonization of these
310 seamounts after the extinction of *A. karsteni* from this latitude during the Miocene.
311 Architectonicids are known to produce teleplanic larvae able to drift in near-surface
312 currents (Scheltema, 1968, 1971; Scheltema and Williams, 1983) and to delay
313 metamorphosis; thus, their larvae can disperse over great distances (1,000's of km under
314 suitable current conditions). In this scenario, the sampled populations would represent
315 recolonization events of this region. Gene flow could exist between populations of the
316 NDMP seamounts and the continental shelf of the Pacific coast of Central America and
317 both populations would be thus be part of a metapopulation.

318 Addressing the history of these populations would thus require appropriate sampling
319 methods to clarify the entire range of the species and to obtain samples suitable for
320 detailed morphological and genetic analysis. Although the systematic position, based on
321 anatomical characters, and complicated taxonomic history of Architectonicidae have
322 been discussed by Haszprunar (1985, 1988) and Bieler (1988, 1992), little attention has
323 been paid to the genetic differences that may exist within and among Architectonicidae
324 species. Therefore, few sequences are available for addressing phylogenetic relationships
325 within Architectonicidae and to assess issues of historic and modern population
326 connectivity. Insufficient genetic data is publicly available, and we did not have access

327 to sufficient samples of *A. karsteni* to determine whether the sampled populations
328 represent relict populations, cryptic species, or a recent colonization of modern *A.*
329 *karsteni*. We accordingly provide barcode data from one of our specimens to aid such
330 future studies. To date, only 63 partial gene sequences are available in GenBank, 50 of
331 which are larval *16S* rDNA sequences from specimens that were not identified below
332 family. Interestingly, only two *COI* sequences are available for Architectonicidae despite
333 this genetic marker being widely used for DNA barcoding of marine species (Bowen et
334 al., 2014). The barcode data provided here was used to confirm the phylogenetic
335 placement of this species relative to Architectonicidae with published *16S* and *COI*
336 sequences. Although the *COI* sequences *A. perspectiva* (FJ917269) and *P. lutea*
337 (AY296843) had a similar percentage of mutations compared with *A. karsteni*, *P. lutea*
338 presents a higher number (6) of non-synonymous mutations across a similar number of
339 base pairs (623 vs 573 bp). In addition, the *16S* rRNA data supports the position of our
340 *A. karsteni* specimen as belonging to the genus *Architectonica*, of which *A. perspectiva*
341 is the type species. Thus, this genetic data from the NDMP specimens are consistent with
342 our classification of *A. karsteni* based on the morphological characteristics. To further
343 elucidate the taxonomic status of this NDMP population and to assess crypticism, future
344 studies should address a more representative genetic sampling of the group, including
345 specimens throughout the entire distributional area.

346

347 CONCLUSIONS

348 Until now, the malacofauna of Salas y Gomez and Nazca Ridge seamounts are considered
349 to have a high affinity with the Indo-Pacific fauna (Parin et al., 1997). However, the
350 recently described species, *Atrimitra isolata*, seems to have morphologic affinities with
351 species from the southeast Pacific coast (Sellanes et al., 2019). Similarly, we we report

352 the presence of a species that was present on the coasts of continental Chile during the
353 Miocene. This new record of *A. karsteni*, together with the discovery of the above
354 mentioned new species in NDMP, highlights the need for more studies of the region,
355 which not only focus on biodiversity but also on the phylogenetic relationships between
356 them and the fauna of surrounding areas.

357

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511 FIGURE LEGENDS

512 **Figure 1:** Extent of *Architectonica karsteni* modern and Miocene geographic distribution
513 and locations of the new records reported here. Live specimens were only collected from
514 seamount SF.5.

515 **Figures 2-7:** Panoramic and zoomed-in images taken with an ROV at the summit
516 seamounts where *Architectonica karsteni* was found. **2.** Panoramic view of SF.6,
517 illustrating the continuous homogeneous bottom of coarse sand with little relief
518 dominated by sea urchins (*Scrippsechinus fisheri*) and sea anemones (Cerianthidae). **3.**
519 Zoomed in view of sea anemones (*Hormathia* sp. and Cerianthidae) and polychaete tubes
520 (*Eunice* sp.) on SF.6. **4.** Panoramic view of SF.9, illustrating the continuous homogeneous
521 bottom of coarse sand with little relief and clusters of maërl-rhodoliths, dominated by sea
522 anemones (Cerianthidae). **5.** Zoomed-in view of sea anemones (Cerianthidae), polychaete
523 tubes (*Eunice* sp.) and sponges on SF.9. **6.** Panoramic view of S21, illustrating the
524 presence of sea anemones (*Hormathia* sp.), sea pens (*Protoptilum* sp.), sand dollars
525 (*Clypeaster isolatus*) and sea urchins (*Scrippsechinus fisheri*) on the continuous
526 homogenous sandy bottom. **7.** Zoomed-in view of sea anemones (*Hormathia* sp.) on S21.
527 Scale bars = 10 cm. Photos credit: Mathias Gorny /Jan M. Tapia

528 **Figures 8-11:** *Architectonica karsteni* sampled in Desventuradas islands (-25.4272°,-
529 81.8806°). **8-9.** Dorsal, lateral and ventral views of specimens 6928a and 6928b (scale
530 bar = 1 cm). **10.** Teleoconch and **11.** protoconch (scale bar = 1mm, SEM) sculpture of
531 SCBUCN 6928a. Arrows in **10** indicate whorl border sutures.

532 **Figure 12:** Maximum-likelihood inferred phylogenetic reconstruction based on 580-bp
533 alignment of partial *COI* sequences of species of Architectonicoidea (*A. karsteni*
534 SCBUCN 7066, Accession GenBank # MN270389 and *A. perspectiva* - FJ917269),
535 Omalogyroidea (*Omalogyra fusca* - FJ917272, *Omalogyra* sp. - FJ917273) and

536 Valvatoidea (*Valvata piscinalis* - FJ917267, *Cornirostra pellucida* - FJ917282). Only
537 bootstrap values above 90 are shown.

538 **Figure 13:** Maximum-likelihood inferred phylogenetic reconstruction based on 415 -bp
539 alignment of partial 16S rRNA 16S sequences of 50 haplotypes of Architectonicidae sp
540 (MH557974 to MH558022), *Architectonica maxima* (KP252986), *A. perspectiva*
541 (FJ9117251), *A. karsteni* (MH270388) and *Psilaxis radiatus* (AY081999).

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547 **Table 1:** Locations and depth of the seamounts sampled; and identification and
 548 measurements (diameter and height) of the *Architectonica karsteni* shells.

Station	Latitude	Longitude	Depth (m)	ID number SCBUCN	Diameter (mm)	Height (mm)	Sample alive
SF.5	-25.4272°	-81.8806°	180	6928a	28.40	15.40	Yes
				6950	22.32	11.20	No
				6926	21.22	10.15	No
				SF.5.029*	26.80	14.70	No
				SF.5.027*	28.44	14.00	Yes
				6928b	25.35	15.30	Yes
				6921	24.87	13.71	No
SF.6	-25.5535°	-82.3963°	176	7066	31.42	17.24	No
SF.9	-25.7774°	-83.3163°	200	6913	14.30	6.40	No
S21	-26.3790°	-79.8893°	150	7135	31.87	17.98	No

549 *This samples do not have SCBUCN numbers but have instead the ID that it was
 550 assigned at the field when they were sampled
 551