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1 **Title**

2 Interspecific difference in the recovery of rocky intertidal zonation after the 2011 Great  
3 East Japan Earthquake

4

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21

22 **Abstract**

23 Both natural and anthropogenic disturbances have significant impacts on populations in  
24 terrestrial and marine habitats. Despite evidence that population recovery after large-scale  
25 disturbances in terrestrial habitats varies substantially among species depending on  
26 species traits and types of disturbance, little is known about interspecific differences in  
27 population recovery in marine habitats. In this study, we evaluated the course and status  
28 of recovery of the vertical distribution of nine intertidal sessile species over 6 years  
29 following the 2011 Great East Japan Earthquake. First, we characterized temporal  
30 changes in the vertical position of zonation as the spatial distribution, and total coverage  
31 as the local population size after the 2011 earthquake. Then, we evaluated the differences  
32 in successional status that explain interspecific differences in zonation recovery speed.  
33 Finally, we revealed that temporal changes in the vertical position and abundance after  
34 the earthquake differed according to species. The interspecific differences in the speed of  
35 recovery of zonation after 2014 were correlated with successional status, with later  
36 successional species having a delayed recovery rate. These results indicated that intertidal  
37 sessile assemblages continued to change 6 years after the large earthquake, suggesting  
38 that evaluations of the impacts of disturbances on assemblages and the course of  
39 community recovery require long periods of time.

40

41 **Keywords**

42 tsunami, subsidence, sessile species, benthic community, species trait

43

44 **1. Introduction**

45 Both natural and anthropogenic disturbances have significant impacts on populations of  
46 various organisms in terrestrial and marine habitats (Nyström, Folke, & Moberg, 2000;  
47 Sousa, 1984; Vörösmarty & Sahagian, 2000; White, 1985). Population recovery after a  
48 disturbance, which can be defined as the recovery of the abundance and distribution of a  
49 population to its natural state prior to the disturbance (Lotze, Coll, Magera, Ward-Paige,  
50 & Airoldi, 2011), varies substantially among species depending on species traits such as  
51 successional status in terrestrial habitats (Lavorel, McIntyre, Landsberg, & Forbes, 1997;  
52 Walker & del Moral, 2009) and the type of disturbance (e.g., Duarte, Conley, Carstensen,  
53 & Sánchez-Camacho, 2009; Kaiser et al., 2006; Worm et al. 2006). Although the type of  
54 disturbance and the species present are clearly distinct between terrestrial and marine  
55 habitats, successional status (i.e., niche position along a successional gradient) are  
56 common traits (Walker & del Moral, 2003). Therefore, successional status probably  
57 explains interspecific differences in population recovery in marine habitat.

58         The Great East Japan Earthquake with Mw 9.0 struck off the Pacific coast of the  
59 Tohoku region of Japan in 2011. The mega-earthquake caused a large tsunami with a  
60 maximum runup height of 40 meters and subsidence of several tens of centimeters  
61 throughout the entire Tohoku region (Lay & Kanamori, 2011; Mori, Takahashi, & 2011  
62 Tohoku Earthquake Tsunami Joint Survey Group, 2012; Mori, Takahashi, Yasuda, &  
63 Yanagisawa, 2011; Tajima, Mori, & Kennett, 2013). Previous studies have suggested that  
64 earthquakes have considerable regional-scale impacts on populations of various marine  
65 benthos (Jaramillo et al., 2012; , Noda, Iwasaki, & Fukaya, 2016a,b; Seike, Shirai, &  
66 Kogure, 2013). This is because the tsunami and land level change caused by earthquakes  
67 can transport sessile organisms to unsuitable habitats (Castilla, 1988; Castilla, Manríquez,

68 & Camaño, 2010; Lomovasky, Firstater, Salazar, Mendo, & Iribarne, 2011; Noda et al.,  
69 2016a,b), affecting the survival and distribution of benthic species.

70 In rocky intertidal habitats, there is a notable vertical environmental gradient due  
71 to the effects of tides and waves (Connell, 1972; Raffaelli & Hawkins, 1996). In the upper  
72 intertidal zone, the immersion period is shorter than that in the lower intertidal zone, and  
73 physical conditions, such as temperatures and desiccation levels, are harsher (Helmuth &  
74 Hofmann, 2001; Menge & Branch, 2001). The magnitude of larval and propagule fluxes  
75 for sessile species is relatively low because these individuals are transported passively by  
76 waves (Bownes & McQuaid, 2006; Bownes & McQuaid 2009; Munroe & Noda, 2009;  
77 Raimondi, 1988). In comparison, in the lower intertidal zone, more species interactions  
78 occur, and predation pressure (e.g., Menge, 1978a,b; Paine, 1971) and species  
79 competition for space (e.g., Chapman, 1990; Connell, 1961a,b; Lubchenco, 1980)  
80 increase. Consequently, sessile species, such as barnacles, mussels, and macroalgae, are  
81 distributed within a vertical range of tens of centimeters; this is known as zonation and it  
82 is a common pattern worldwide (e.g., Dayton, 1971; Lewis, 1964; Menge, 1976;  
83 Stephenson & Stephenson, 1972).

84 The zonation of sessile species (i.e., their vertical position and abundance) along  
85 the Pacific coast of Tohoku region was altered by the Great East Japan Earthquake in  
86 2011. This change in zonation was assumed to be the result of subsidence because the  
87 negative impacts of the tsunami on the abundance of sessile species was negligible  
88 (Iwasaki, Fukaya, & Noda, 2016; Iwasaki & Noda, 2018; Noda et al., 2016 a,b; see  
89 Supplemental Materials for details). Subsequently, zonation should be affected by the  
90 recruitment and mortality of sessile organisms. While previous studies have demonstrated  
91 that the dynamics of rocky intertidal zonation after the earthquake varied substantially

92 among species, the causes of these interspecific differences have not been examined  
93 (Noda et al. 2016a,b). Therefore, we hypothesized that interspecific differences in the  
94 speed of recovery of zonation can be explained by differences in the successional status  
95 of each species. Because early successional species exhibit greater recruitment of larvae  
96 or propagules and faster population growth after recruitment than late successional  
97 species (Farrell 1991), their zonation is likely to recover more quickly after an earthquake  
98 compared with later successional species.

99 In this paper, we report the course and status of recovery of the vertical  
100 distribution of nine rocky intertidal sessile species at 23 sites, located 150–160 km  
101 northwest of the epicenter of the 2011 Great East Japan Earthquake, over 6 years. First,  
102 we characterize temporal changes in the vertical position of zonation as the spatial  
103 distribution and total coverage as the local population size after the earthquake in 2011.  
104 Then, we evaluate the differences in successional status, a factor that could potentially  
105 explain interspecific differences in zonation recovery speed.

106

## 107 **2. Materials and Methods**

### 108 **2.1 Study area**

109 The study area was located along 30 km of coastline on the Sanriku Coast of Japan (Fig.  
110 1). The study shores were 150–160 km north-northwest of the epicenter (38°06'12.0"N  
111 and 142°51'36.0"E) of the Great East Japan Earthquake, which caused large tsunami  
112 waves (run-up height, several to 30 m) and subsidence of 50–60 cm throughout the area  
113 (Lay & Kanamori, 2011; Noda et al., 2016a; Tajima et al., 2013). Low tide occurs during  
114 the day from April to September and at night from October to March. Dominant sessile  
115 species were the bivalves *Crassostrea gigas* and *Septifer virgatus*, the barnacles

116 *Chthamalus challengeri* and *Semibalanus cariosus*, and the perennial algae *Gloiopeltis*  
117 *furcata*, *Analipus japonicus*, and *Hildenbrandia rubra*. Detailed information about biota  
118 is provided in Okuda, Noda, Yamamoto, Ito, and Nakaoka (2004), Nakaoka, Ito,  
119 Yamamoto, Okuda, and Noda (2006), and Fukaya, Okuda, Nakaoka, Hori, and Noda  
120 (2010).

121

## 122 **2.2 Census design**

123 A hierarchical sampling design (Noda 2004) was applied for a census of five shores  
124 separated by 2.6–7.9 km (Fig. 1). In July 2003, four or five sites within each shore were  
125 chosen and two permanent rectangular plots were established within each site: control  
126 plots and succession plots. Control plots were un-manipulated, and succession plots were  
127 cleared of all organisms on the rock surfaces in July 2003 by burning with gas torches  
128 and scratching with wire brushes. Each control and succession plot was 50 cm wide by  
129 100 cm high, and the mean tidal level corresponded to the vertical midpoint.

130 Each control plot was extended 100 cm above in July 2011 (Fig. 2) because the  
131 study area experienced subsidence due to the Great East Japan earthquake; vertical  
132 subsidence was 50 cm at four shores (Myojin, Oura, Aragami, and Katagishi) and 60 cm  
133 at Akahama (Noda et al. 2016a). Consequently, the vertical observation range for each  
134 control plot was 200 cm after the earthquake. Here, it is noted that although uplift can  
135 occur after subsidence, the effect of the uplift that occurred after the subsidence in the  
136 study area was negligible due to the small range, which was about 2cm over the 6 years  
137 following the earthquake (The Coordinating Committee for Earthquake Prediction, Japan,  
138 2017).

139 Each control plot was divided vertically into subsections every 10 cm from the

140 upper edge; a plot had 10 and 20 subsections before and after the earthquake, respectively.  
141 In each subsection, 20 grid points were placed on the rock surface at 5-cm intervals in  
142 both the vertical and horizontal directions in each control plot. To estimate coverage as  
143 abundance, each sessile organism occupying a grid point was identified and recorded, and  
144 the total number of grid points for each sessile organism in each subsection was  
145 determined in each census. This census was carried out in July from 2004 to 2017 at low  
146 tide.

147 Each succession plot was divided vertically into subsections at 10-cm intervals;  
148 a plot had 10 subsections. In each subsection, the occurrence (i.e., presence or absence)  
149 of sessile organisms was recorded. This census was carried out each July from 2004 to  
150 2010 at low tide.

151

152

### 153 **2.3 Data analysis**

154 To characterize the temporal changes in the vertical position of zonation as well as total  
155 coverage, the data from the entirety of the control plots (50 cm width  $\times$  200 cm height;  
156 Fig. 2 “raw zonation”) was used for two reasons. First, most of the vertical range of  
157 zonation of the focal species should be covered by the spatial scale of observation to  
158 reliably estimate its recovery rate. Second, sufficient numbers ( $\sim 10$ ) of species are  
159 required to perform statistical tests. The specific methods for characterizing temporal  
160 changes in vertical position and total coverage are described below in the section  
161 *Quantifying zonation*. To estimate the rate of population recovery after the earthquake,  
162 the zonation before the earthquake was defined as the zonation of the control plots in July  
163 2011, which was shifted 50–60 cm upward (Fig. 2, “zonation of orange line”). Next, the

164 zonation after 2012 was compared with the zonation before the earthquake within the  
165 same tidal range; the data from the upper 50 cm before the earthquake and from the lower  
166 50 cm after 2012 were not used for analysis (Fig. 2, “pink area”). The specific methods  
167 for the estimation are described below in the section *Recovery of zonation after the*  
168 *earthquake*. To estimate the species’ successional status, the data from the succession  
169 plots were used. The specific methods for estimation are described below in the section  
170 *Successional status*.

171

#### 172 *Species selection*

173 We selected only common native species for analysis; invasive species (e.g., *Balanus*  
174 *grandula*) found in the study area were excluded. Additionally, species with a temporal  
175 mean value of coverage both before and after the earthquake lower than 0.5% were  
176 excluded. For species with low coverage, the vertical distribution and coverage can  
177 include large observation error, making it difficult to accurately estimate their zonation  
178 and/or coverage. Finally, species whose zonation changed between the time of the  
179 earthquake (i.e., March 11, 2011) and July 2011 were excluded. To evaluate this, the  
180 mean zonation from 2003 to 2010 was compared with the zonation after the earthquake  
181 (the zonation in July 2011 was shifted 50 cm upward) by using the Kolmogorov–Smirnov  
182 test.

183         Based on the above criteria, nine sessile species were included in subsequent  
184 statistical analyses: four sessile animals (*Chthamalus challengerii*, *Hydroides ezoensis*,  
185 *Crassostrea gigas*, and *Septifer virgatus*) and five algae (*Condrus yendoii*, *Gloiopeltis*  
186 *furcate*, *Hildenbrandia rubra*, *Analipus japonicus*, and Corallinales spp.).

187

188 *Quantifying zonation*

189 Using the data accumulated from all control plots, the vertical distribution of each species  
190 was obtained in each year as the mean coverage at the elevation of each of the subsection  
191 relative to the mean tidal level. As a measure of the vertical position of zonation (i.e., the  
192 spatial distribution of a species), the height corresponding to quartiles of the cumulative  
193 frequency distribution (i.e., 25th, 50th, and 75th percentiles) along the tidal height was  
194 calculated for each species in each year. In addition, as a measure of total coverage of the  
195 local population, the sum of the mean coverage of each species was calculated in each  
196 year for control plots.

197

198 *Recovery of zonation after the earthquake*

199 The recovery rate of zonation  $t$  years after the earthquake was calculated as the similarity  
200 between the zonation before the earthquake and in each year after the earthquake (i.e.,  
201 from 2012 to 2017) using Bray–Curtis index as follows:

202 
$$\delta_{i,t} = 1 - \frac{\sum_h |N_{i,h}^{(before)} - N_{i,h,t}|}{(\sum_h N_{i,h}^{(before)} + \sum_h N_{i,h,t})}$$

203 Here,  $N_{i,h}^{(before)}$  is the coverage before the earthquake in species  $i$  at subsection  $h$  (i.e.,  
204 the zonation in July 2011 being shifted 50 cm upward) and  $N_{i,h,t}$  is the coverage  $t$  years  
205 after the earthquake in species  $i$  at subsection  $h$ . Bray–Curtis dissimilarity ranges from 0  
206 to 1, and  $\delta_{i,t}$  values near 1 indicate that zonation is highly similar before and after the  
207 earthquake.

208

209 *Successional status*

210 As mentioned earlier, successional status is a species trait that may explain interspecific

211 differences in recovery rates. Successional status was estimated using Usher's succession  
212 index for species  $i$ ,  $M_i$ , as follows (Usher 1970):

$$213 \quad M_i = \frac{\sum_t y_i f_{i,t}}{F_{i,t}}.$$

214 Here,  $y_i$  is the years elapsed when 2004 is set to 1,  $f_{i,t}$  is the occurrence frequency of  
215 species  $i$  in the year  $t$  (i.e., from 2004) in the succession plot, and  $F_{i,t}$  is the sum of  
216 occurrence frequencies of species  $i$  from 2004 to 2010.  $M_i$  is larger if species  $i$  occurs in  
217 late successional stages.

218

### 219 *Statistical analyses*

220 The correlation between the recovery rates after the earthquake and successional status  
221 (i.e., Usher's succession index) was evaluated by Spearman's rank correlation coefficient.  
222 These statistical analyses were implemented in R 3.5.0 (R Development Core Team,  
223 2018).

224

225

## 226 **3. Results**

### 227 **3.1 Changes in zonation after the earthquake**

228 Although all species exhibited upward shifts in their vertical positions of zonation after  
229 the earthquake, temporal patterns differed according to species (Figs. 3–4). In *C.*  
230 *challengeri*, *C. gigas*, *G. furcate*, and *A. japonicus*, the recovery of the vertical position  
231 was nearly complete within a few years after the earthquake. In others (i.e., *H. ezoensis*,  
232 *S. virgatus*, *C. yendoi*, *H. rubra*, and Corallinales spp.), the upward shifts were more  
233 gradual. The vertical positions of *S. virgatus* and *C. yendoi* varied among years.

234 Although the total coverage of most species increased immediately after the

235 earthquake, subsequent changes differed among species (Fig. 5). In *C. challengerii*, *C.*  
236 *gigas*, *G. furcata*, *A. japonicus*, and Corallinales spp., the total coverage increased in 2012  
237 and fluctuated after 2013. In *H. ezoensis*, the total coverage increased. In *H. rubra* and *S.*  
238 *virgatus*, the total coverage decreased until 2015 and increased gradually thereafter.

239

### 240 **3.2 Recovery of zonation after the earthquake**

241 Temporal changes in recovery rates differed among species (Fig. 6). In *C. challengerii*  
242 and *H. ezoensis*, recovery rates increased by 2013 and then gradually decreased. In  
243 contrast, in *C. gigas*, *S. virgatus*, *C. yendoii*, *G. furcata*, and Corallinales spp., recovery  
244 rates decreased immediately after the earthquake and then increased slightly. In *H. rubra*  
245 and *A. japonicus*, recovery rates showed relatively little change during the study period.

246

### 247 **3.3 Relationship between recovery rate and successional status**

248 The correlations between the recovery rate and Usher's succession index were always  
249 negative (Fig. 7). The correlation tended to be stronger after 2014, but statistical  
250 significance was only obtained in 2016.

251

252

## 253 **4. Discussion**

254 Although the vertical position of zonation shifted upward after the earthquake in all  
255 species (Figs. 3–4), temporal changes in coverage differed among species (Fig. 5).  
256 Coverage increments accompanying the expansion of the vertical range of zonation,  
257 which were detected for *C. challengerii*, *H. ezoensis*, *C. gigas*, *G. frucata*, *A. japonicus*,  
258 and Corallinales spp., suggested that the increase in coverage by recruitment and

259 subsequent growth at the upper part of the zone was greater than the decline of coverage  
260 caused by death at the lower part of the zone. In contrast, the coverage decline  
261 accompanied by an upward shift of zonation, as detected for *H. rubra*, *S. virgatus*, and *C.*  
262 *yendoii*, suggests that the increment of coverage caused by recruitment and subsequent  
263 growth at the upper area was smaller than the decline of coverage caused by death at the  
264 lower area.

265         The negative correlation between the recovery rate and Usher’s succession index  
266 tended to be stronger after 2014 (Fig. 7). While the recovery rates of early successional  
267 species did not change over time, those of intermediate and late species decreased,  
268 resulting in a negative correlation. Thus, the obtained results supported our prediction  
269 (i.e., pattern) that recovery rates of zonation are likely to be faster for early successional  
270 species than for late successional species. However, the impacts of the disturbance on  
271 intermediate and late successional species had a time lag, and the mechanism underlying  
272 the negative correlation may be complex.

273         The recovery rates of intermediate and late successional species were lower than  
274 those of early successional species, even in 2017 (Fig. 7). It is possible that intermediate  
275 and late successional species needed more time for population recovery after such a “giant”  
276 disturbance. The species with low recovery rates even in 2017, *C. gigas*, and *S. virgatus*  
277 (Fig. 7), act as facilitators for small sessile animals and mobile invertebrates by reducing  
278 abiotic stresses such as desiccation and biotic stresses such as predation (Witman 1985).  
279 Therefore, the low recovery rates of these species may be related to the community  
280 structure in intertidal assemblages.

281         Our results showed that temporal changes in coverage after subsidence were  
282 distinct among nine sessile species (Fig. 5). These findings are not consistent with

283 previous studies of similar taxonomic assemblages showing that the temporal change in  
284 coverage after uplift did not differ among species; most species experienced immediate  
285 mass mortality and subsequent declines in coverage after the Chilean earthquake in 1985  
286 (Castilla, 1988; Durán & Castilla, 1989). This indicates that the temporal change in the  
287 coverage of sessile species after an earthquake with subsidence is more complex and  
288 variable than that with uplift. It might be caused by the more complex population  
289 processes after subsidence than uplift. Shifts in sessile organisms beyond the lower limits  
290 of zonation can cause transient increases in body growth by increasing the immersion  
291 period (Raffaelli & Hawkins, 1996) and can often cause a gradual rise in mortality by  
292 increasing the intensity of competition and consumption (Connell, 1972; Paine, 1974;  
293 Underwood & Denley, 1984). Shifts beyond the upper limits of zonation can cause an  
294 immediate increase in mortality by physical stress, including thermal stress and  
295 desiccation (Helmuth, Mieszkowska, Moore, & Hawkins, 2006; Underwood & Denley,  
296 1984). Furthermore, this difference in complexity in the temporal change of coverage  
297 after the earthquake between cases of subsidence and uplift suggests that the same kind  
298 of disturbance (i.e., an earthquake) can be followed by a highly different recovery process  
299 depending on the conditions (i.e., direction of land level change).

300 Our results show that zonation of the sessile community had not recovered to the  
301 pre-earthquake state 6 years after the earthquake; in most species, vertical distribution,  
302 total coverage, and vertical position of zonation continued to fluctuate and their recovery  
303 rates remained low (Figs. 3–6). By comparing the temporal change in zonation between  
304 after subsidence following this earthquake and after uplift following the Chilean  
305 earthquake in 1985, the time to recovery of zonation of the sessile community after the  
306 land deformation and the difference depending on the direction of land deformation can

307 be predicted as follows. First, the recovery of zonation of the sessile community will  
308 require more than a few years either after subsidence or uplift. This is because the  
309 zonation of the sessile community did not recover to the pre-earthquake state 6 years after  
310 subsidence and 3 years after uplift, respectively. These findings suggest that the sessile  
311 community periodically experiences drastic changes in zonation and the recovery phase  
312 for several years in plate boundary areas where large earthquakes (>Mw 8.0) occur  
313 cyclically at intervals of decades or centuries (Ammon, Lay, & Simpson, 2010; Lay &  
314 Kanamori, 2011). Second, communities dominated by mussels will need more time to  
315 recover after subsidence (Rilov & Schiel, 2006) than after uplift. Mussels are apparently  
316 more vulnerable to increases in predation pressure caused by subsidence than to increases  
317 in physical stress caused by uplift. For example, *S. virgatus* decreased drastically by  
318 subsidence after this earthquake and did not recover in the 6 years following the  
319 earthquake (Fig 4). The mussel *Perumytilus purpuratus* did not decrease by uplift after  
320 the Chilean earthquake (Castilla, 1988, Durán & Castilla, 1989) but decreased drastically  
321 by an increase in the predator *Concholepas concholepas* caused by the exclusion of the  
322 top predator, humans (Durán & Castilla, 1989). These findings emphasize the importance  
323 of collecting information about the recovery process following an earthquake by long-  
324 term observation to reveal how the sessile community is determined and maintained at a  
325 large temporal scale.

326

### 327 **Conclusion**

328 We characterized the course and status of recovery of the vertical distribution of nine  
329 intertidal sessile species within 6 years after a mega-earthquake, the 2011 Great East  
330 Japan Earthquake. Temporal changes in vertical position and total coverage after the

331 earthquake differed according to species. Interspecific differences in the speed of  
332 recovery of zonation were correlated with successional status, with delayed recovery in  
333 later successional species. Based on our results, we obtained two major conclusions. First,  
334 successional status is likely to be an inherent species trait that is independent of habitat  
335 and can explain interspecific differences in population recovery. Second, intertidal sessile  
336 assemblages continued to change 6 years after the earthquake, suggesting the need for  
337 long-term monitoring to evaluate the impacts and the course of community recovery.

338

339

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354

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## 585 **Figure legends**

586 **Fig. 1** Study site location. Five shores were chosen for the census of intertidal  
587 organisms on the Sanriku coast along the Pacific coast of Japan. Cross mark represents  
588 the epicenter of the Great East Japan Earthquake

589 **Fig. 2** Conceptual diagram of the vertical range between census and analytic region

590 **Fig. 3** Course and status of the recovery of the vertical distribution of rocky intertidal  
591 sessile organisms within 6 years after the mega-earthquake along the coast at locations  
592 150–160 km north-northwest of the epicenter of the 2011 Great East Japan Earthquake

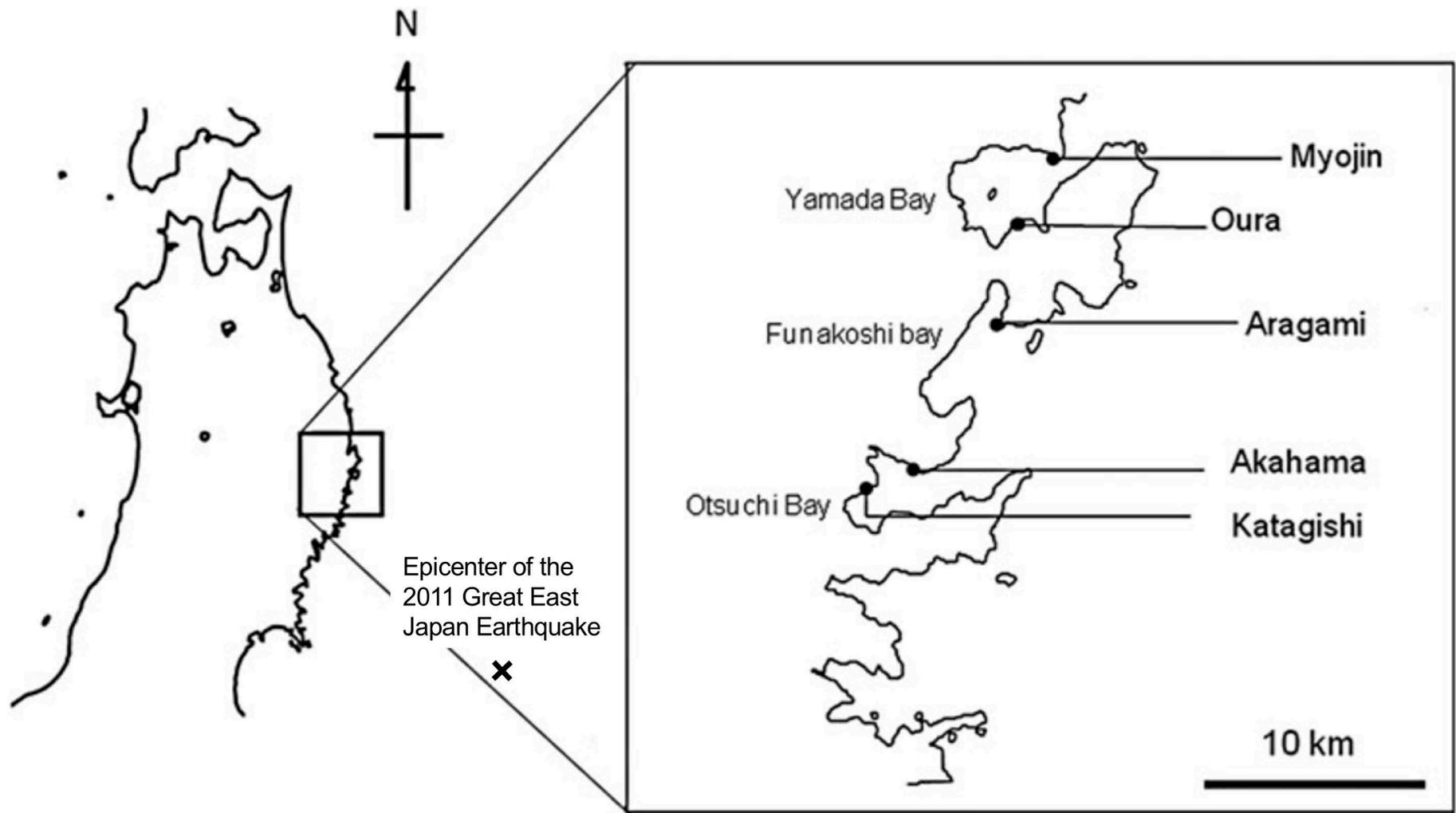
593 **Fig. 4** Annual changes in the 25%, median, and 75% values in the cumulative frequency  
594 distribution of coverage in the vertical direction after the 2011 Great East Japan  
595 Earthquake

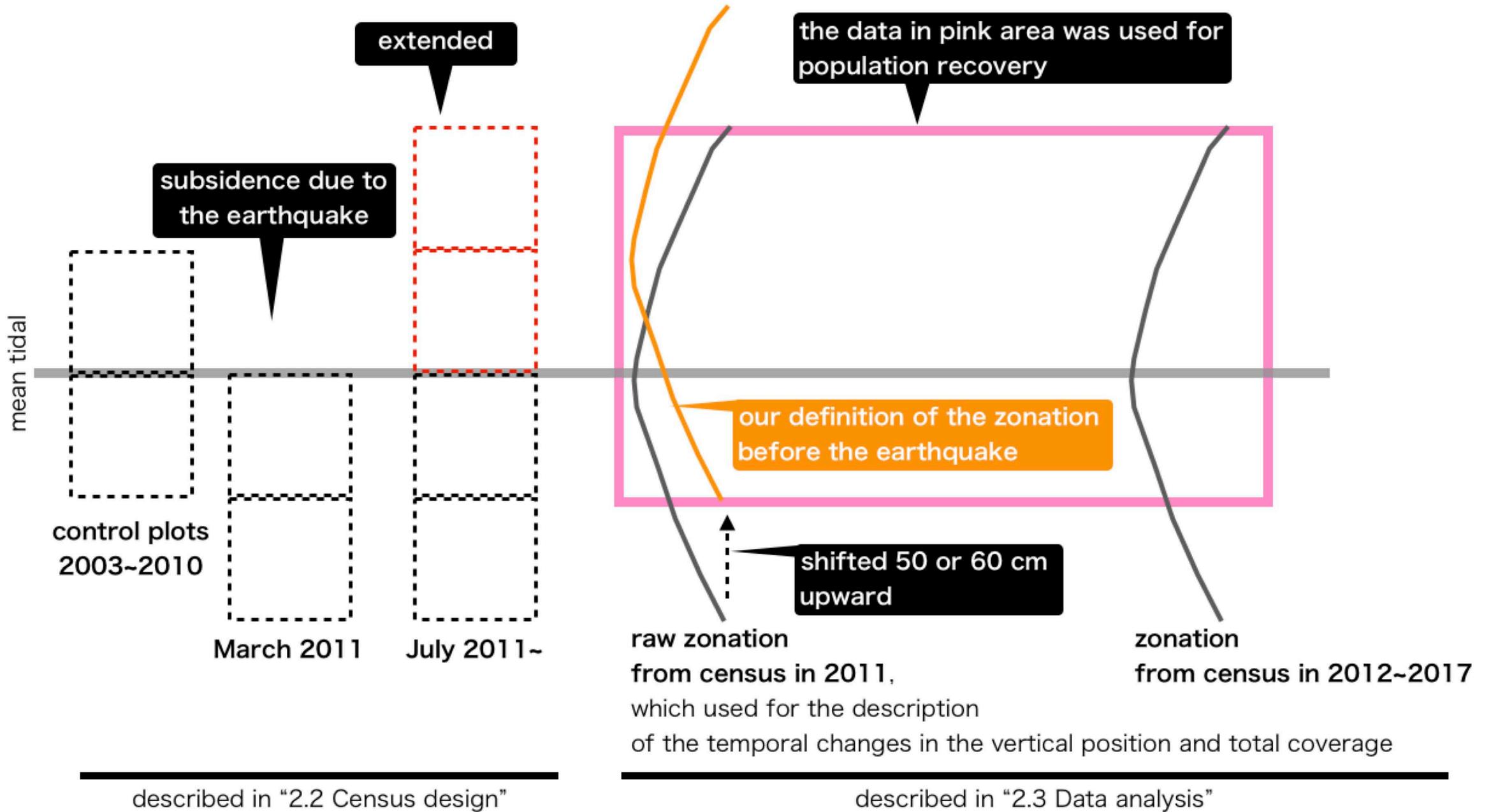
596 **Fig. 5** Annual change in the total coverage of each species after the 2011 Great East  
597 Japan Earthquake

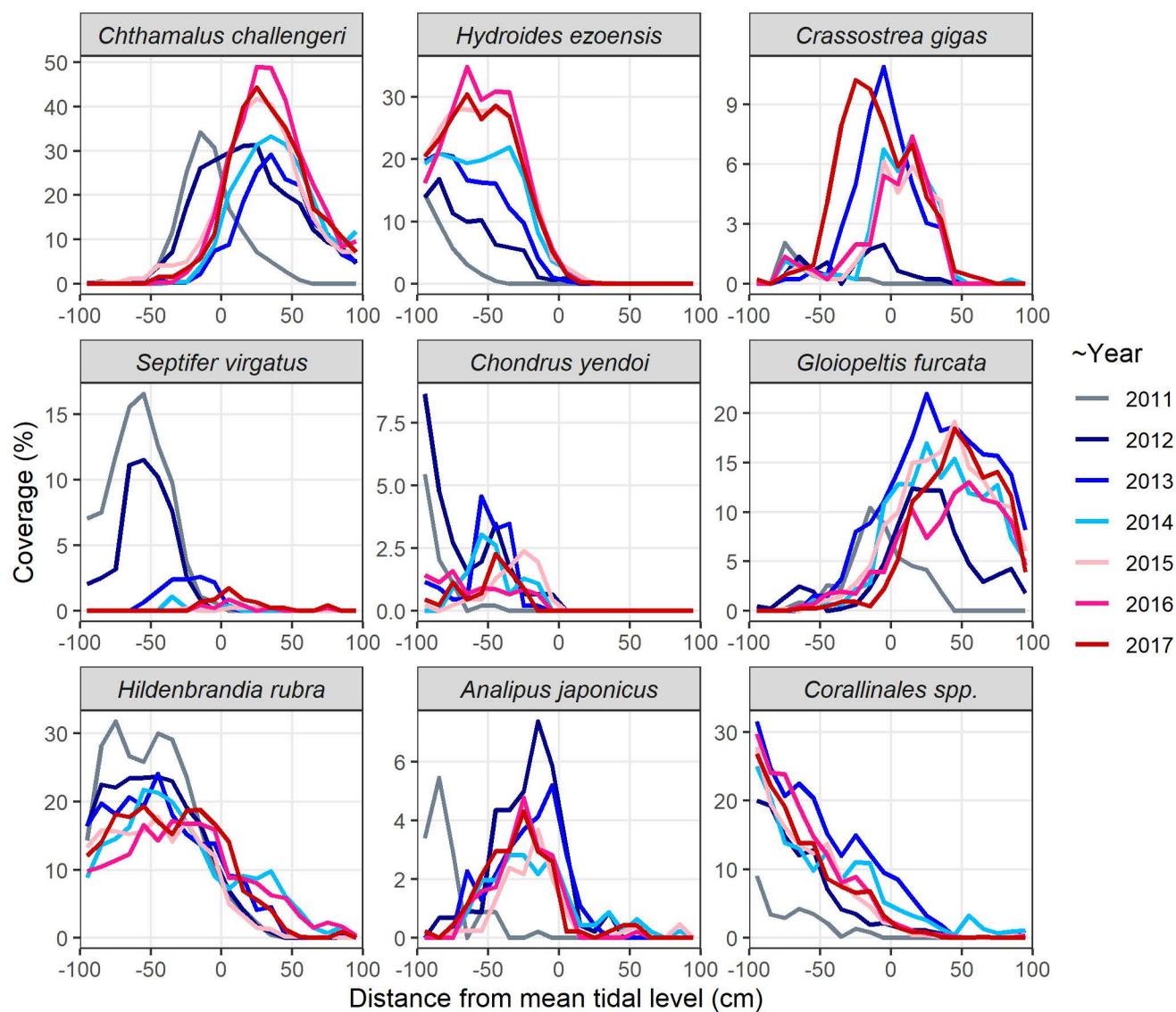
598 **Fig. 6** Recovery rate for each species after the 2011 Great East Japan Earthquake

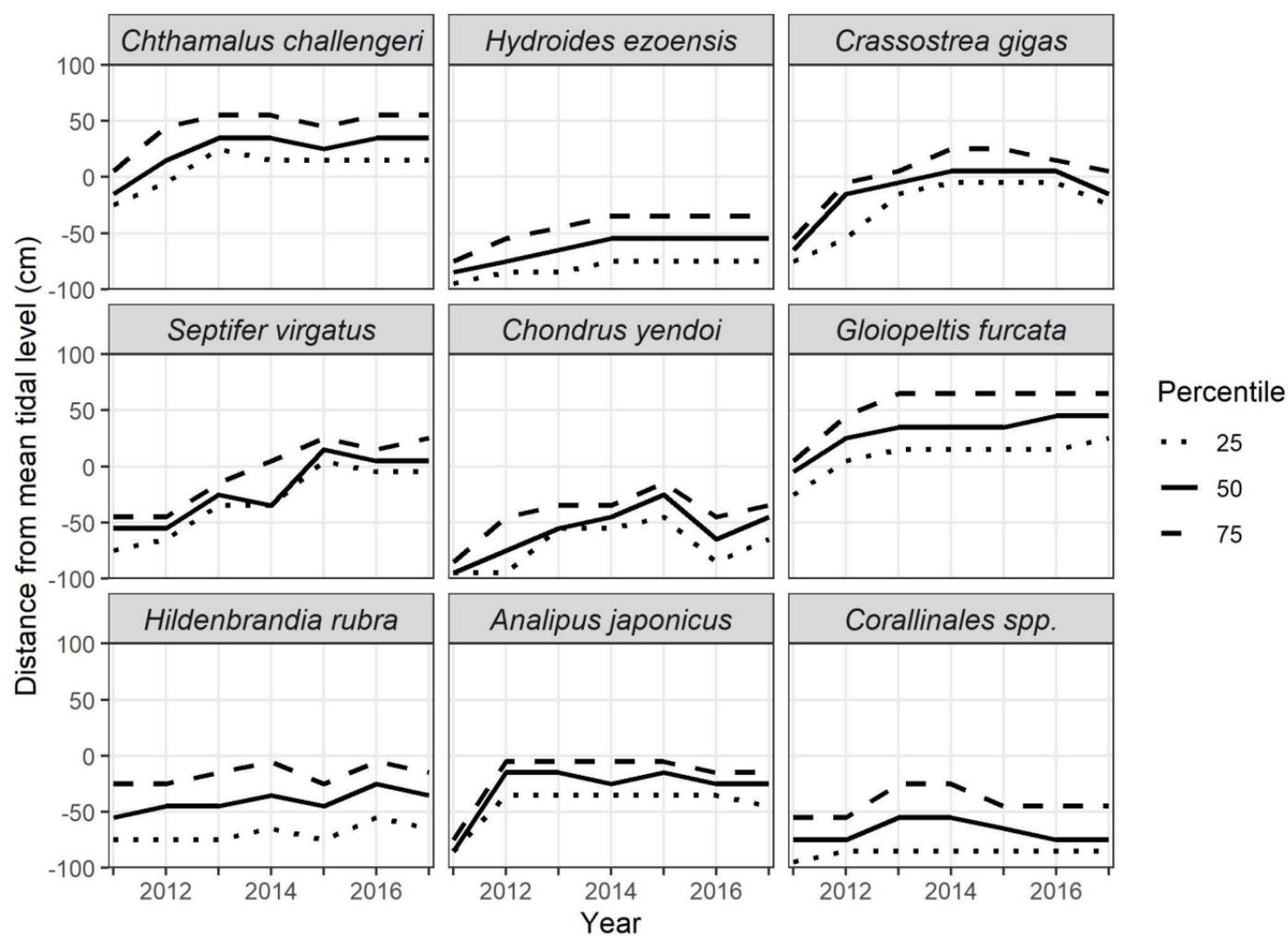
599 **Fig. 7** Relationship between the recovery rate and Usher's succession index

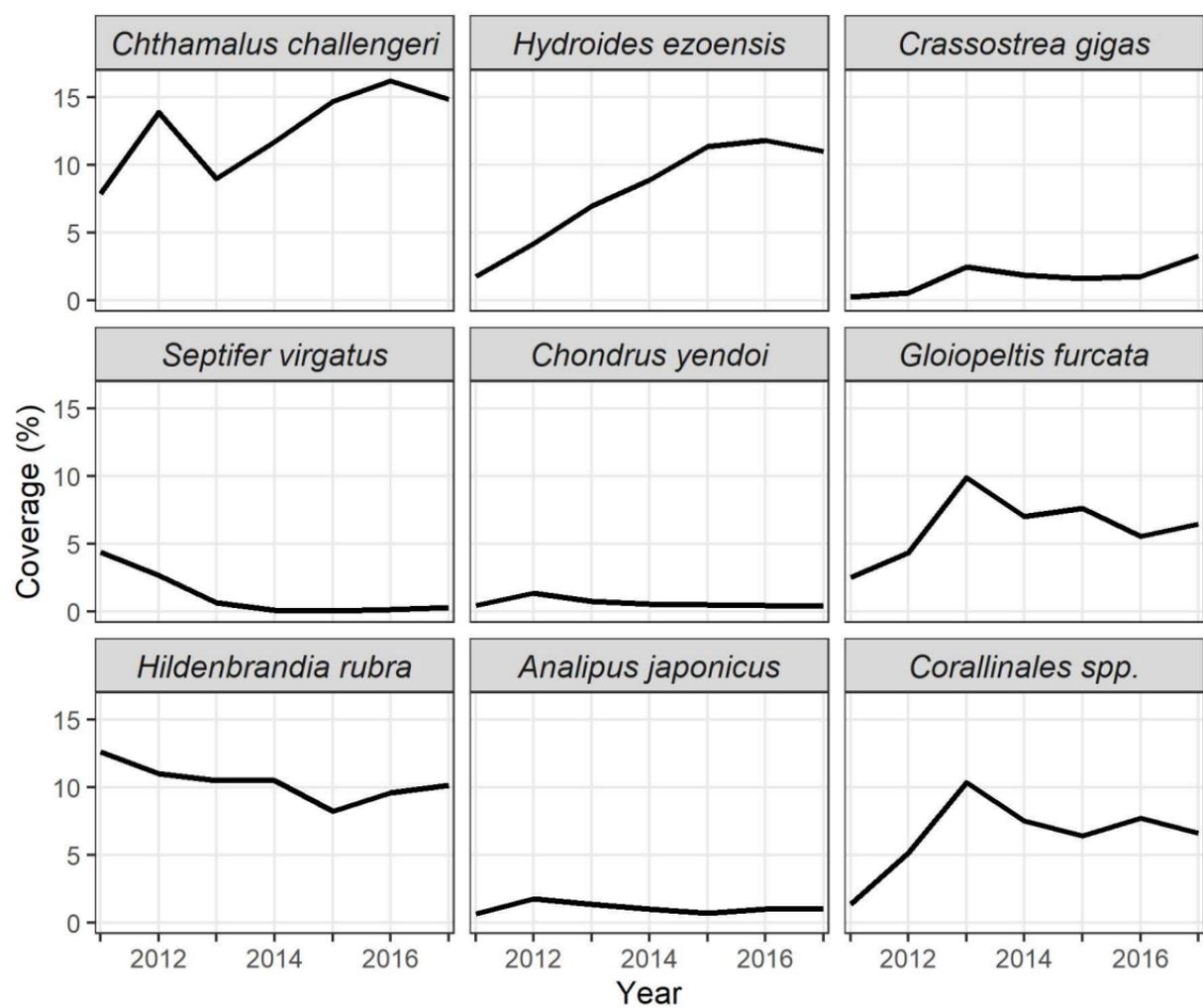
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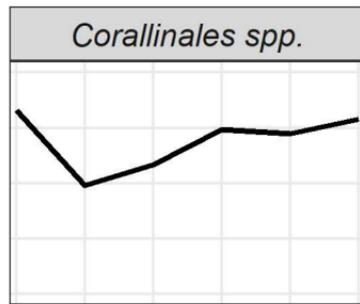
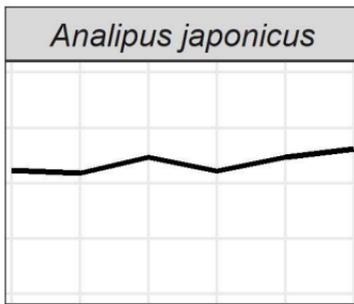
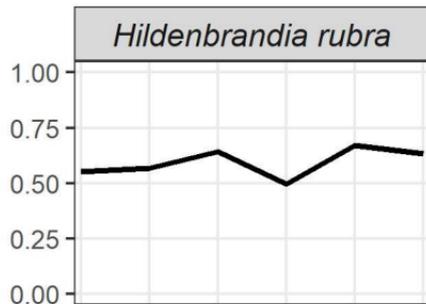
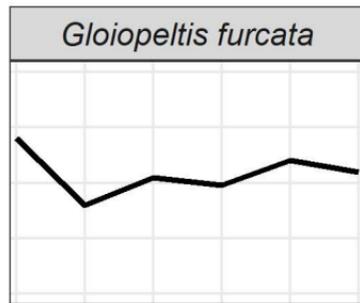
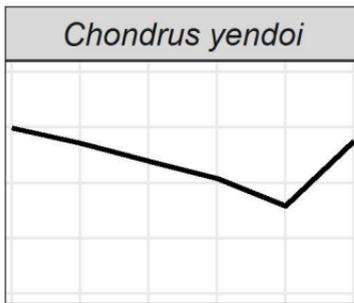
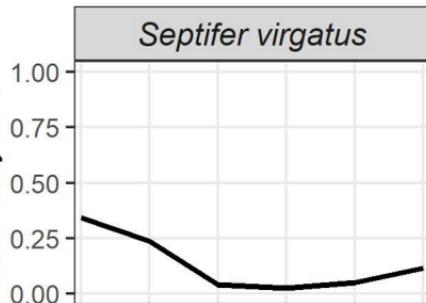
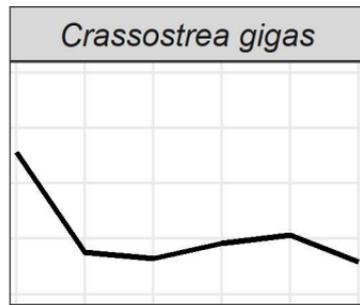
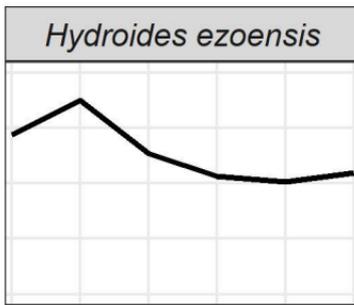
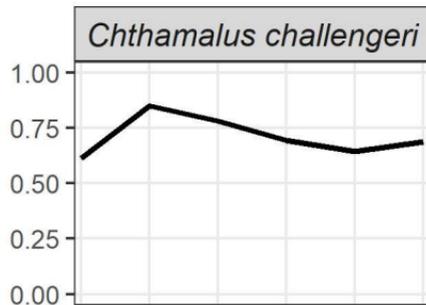












Recovery rate

2012

2014

2016

2012

2014

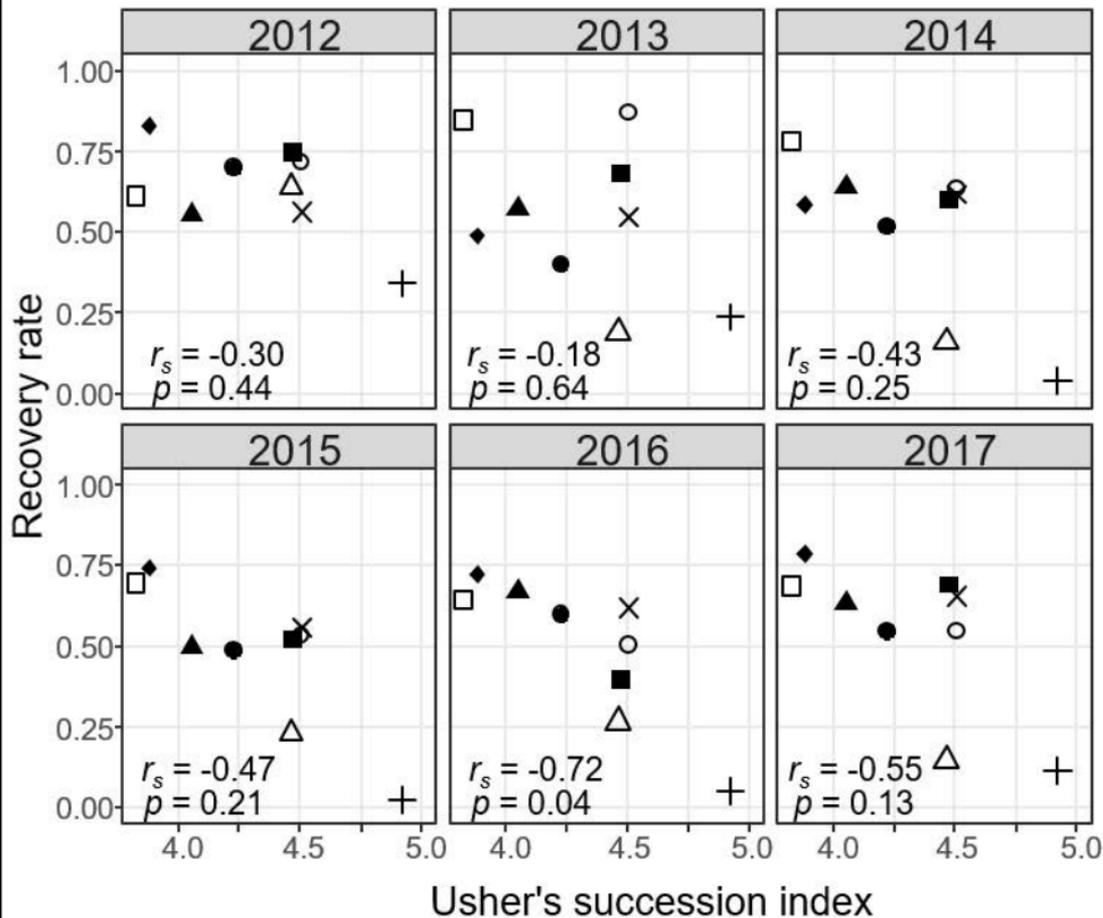
2016

2012

2014

2016

Year



### Species

- *Chthamalus challengerii*
- *Hydroides ezoensis*
- △ *Crassostrea gigas*
- + *Septifer virgatus*
- *Chondrus yendoii*
- *Gloiopeltis furcata*
- ▲ *Hildenbrandia rubra*
- × *Analipus japonicus*
- ◆ *Corallinales* spp.