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1 **The impact of potting for crustaceans on temperate rocky reef habitats: implications for**
2 **management**

3

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15

16 **ABSTRACT**

17 Multi-use marine protected areas (MPAs) are increasingly designated towards achieving
18 global conservation targets. To develop effective management, the impact of permitted
19 activities must be understood. Potting for shellfish occurs on temperate rocky reefs globally
20 with impact not fully quantified. This UK-based study used underwater video to quantify (a)
21 benthic condition of rocky reefs, (b) mechanisms of potting interaction and (c) true footprint
22 of potting. Assemblages in static gear areas were more indicative of a healthy reef than those
23 in mixed gear areas. Damage was recorded during pot hauling, but the area of damage was
24 not the entire pot haul path. 25-30 % of individuals were damaged (commonly through tissue
25 abrasion) or removed. Notably, damage occurred to some long-lived, slow growing taxa
26 raising concerns over impacts. Potting is more destructive than previously thought and

27 managers must balance ecology with social and economic considerations to determine what
28 level of impact is acceptable.

29

30 **HIGHLIGHTS**

- 31 • Impacts of potting on UK temperate rocky reefs quantified using underwater video
- 32 • Novel method using GoPro cameras to observe direct potting impacts
- 33 • Areas fished with pots characterised by species indicative of a healthy reef system
- 34 • Damage to long lived, slow growing taxa of potential concern
- 35 • Managers must decide what level of impact is 'acceptable'

36

37 **KEYWORDS**

38 Potting; *fishery management*; static gear; temperate rocky reef; *benthic ecology*; marine
39 protected areas; *conservation*; underwater video; impact assessment; monitoring

40

41 **1. INTRODUCTION**

42

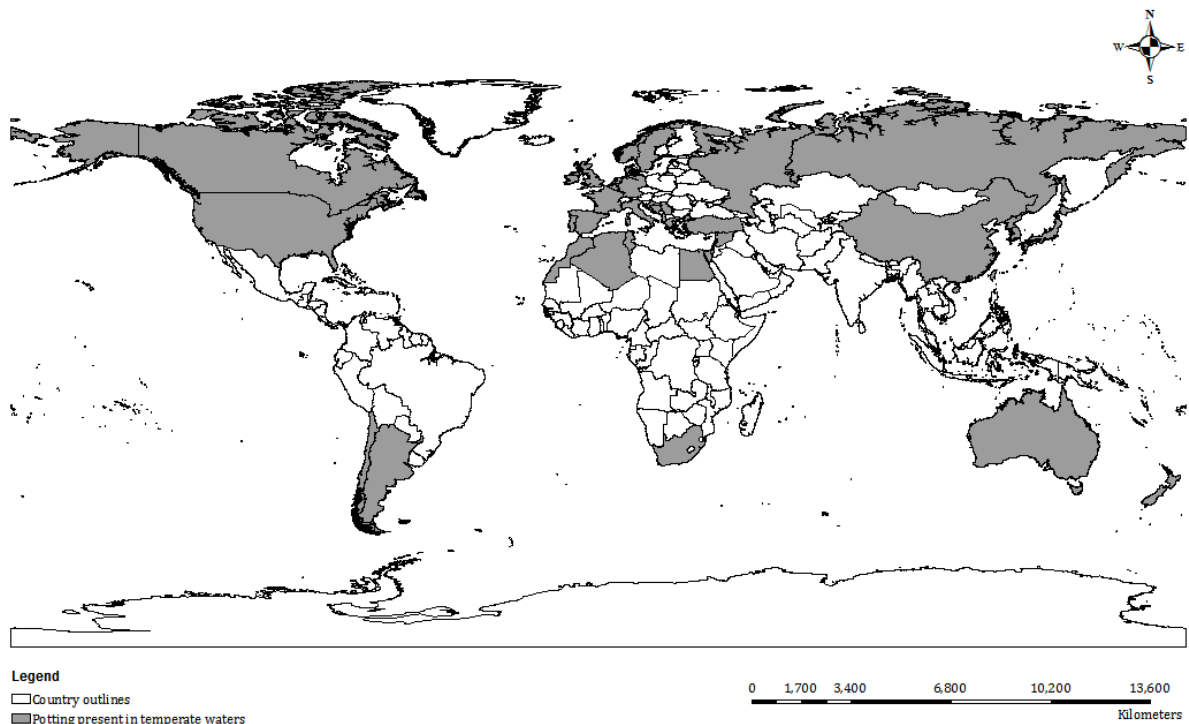
43 Temperate rocky reefs are characterised by sensitive, emergent epifauna, which are often
44 long lived, slow growing and sensitive to human impacts. They provide important topographic
45 complexity, and support commercially important species through, for example, provision of
46 nursery areas, refuges from predators and habitat for the settlement of invertebrate spat
47 (Beaumont, 2009; Beck et al., 2001; Beukers-Stewart and Beukers-Stewart, 2009; Dayton et
48 al., 1995; Grecian et al., 2010; Hiddink et al., 2011; Jennings and Kaiser, 1998; Jennings et al.,
49 2001; Monteiro et al., 2002; Parsons et al., 2016; Ryer et al., 2004). These systems are

50 vulnerable to habitat destruction caused by fishing gear impacting the benthos (Gray, 1997;
51 Gray et al., 2006; Kaiser et al., 2006; Sangil et al., 2013; Sheehan et al., 2017). The
52 consequences of this are varied, but may result in broad scale, assemblage level change such
53 as change in species composition, reduction in biomass, diversity and productivity and the
54 removal of key species, all of which compromise the resilience of the ecosystem and its role
55 in providing habitat to support species of commercial importance (Auster et al., 1996;
56 Bradshaw et al., 2002; Collie et al., 1997; Jennings and Kaiser, 1998; Roberts and Polunin,
57 1991). Complexity and biodiversity within an ecosystem are key to its resilience, and are
58 consequently of key relevance to marine conservation and human wellbeing (Cardinale et al.,
59 2012; Howarth et al., 2014). Thus, in order to maintain the ecosystem services provided by
60 rocky reefs it may be necessary for management measures to be implemented to reduce the
61 impact of damaging fishing activities on sensitive habitats and species (Worm et al., 2006).

62

63 The coastal location of temperate rocky reefs makes them easily accessible for vessels of any
64 size and they are targeted by commercial fisheries across the globe (Figure 1). In particular,
65 these areas are favoured by fisheries for crustaceans, such as crab and lobster, which inhabit
66 rocky reefs, or softer sediment occurring in areas between and within rocky reef patches
67 (Howard and Bennett, 1979; Martel et al., 1986; Sheehan et al., 2013a). Crustacean fisheries
68 associated with rocky reefs occur as a global industry throughout the northern and southern
69 temperate zones, present in 48 countries, which also have multi-use MPAs within their waters
70 (data derived through literature review; Figure 1). They are commonly located in inshore,
71 shallow reef areas and target species include, for example, edible crab (*Cancer pagurus*) in
72 north west Europe (e.g. Bannister, 2009; FAO, 2017), Juan Fernández rock lobster (*Jasus*

73 *frontalis*) in Chile (e.g. Arana et al., 2011), mud crab (*Scylla* spp.) in Africa (e.g. Le Vay, 2001)
74 and spiny red rock lobster (*Jasus edwardsii*) in Southern Australia (e.g. Treble et al., 1998).



75

76 **Figure 1: Global map showing countries where potting is conducted in temperate waters**
77 **and where multi-use MPAs exist. Data sourced from literature searches. Map created using**
78 **ArcGIS 2017.**

79

80 Crustacean fisheries are a very valuable component of the UK fishing industry, with 1,342
81 vessels fishing with pots and traps in 2016; the majority of which were under 10m vessels
82 fishing in inshore waters (Seafish, 2017). In 2017, total shellfish landings accounted for 38 %
83 of all landings by UK vessels into the UK and abroad, and during the year of 2017, 34,100
84 tonnes of crab and lobster were landed into the UK by UK vessels, worth £98.1 million (MMO,
85 2018).

86

87 The most common method of capture for crustacean species are pots and traps (termed ‘pots’
88 from here on in). All pots are referred as “static gear” as they are deployed and left to soak

89 in situ, before being hauled after a period of time. The design and material of the pots varies
90 between locations, with pots made of wood, metal or plastic, but all share this common mode
91 of operation, meaning that the impacts may be assumed to be broadly similar (Slack-Smith,
92 2001).

93

94 Where MPAs are designated to protect temperate rocky reefs it is possible that they will
95 overlap with areas where pot fishing occurs, and, as potting has commonly been an activity
96 assumed to have little or no impact (Jennings & Kaiser, 1998), it is often permitted where
97 MPAs are multi-use. There is, however, increasing attention placed on this, with researchers
98 and policy makers wishing to understand more about potential impacts from potting to
99 ensure such activities are compatible with the conservation goals of MPAs (e.g. Casement and
100 Svane, 1999; Coleman et al., 2013; Eno et al., 2001; Lewis et al., 2009; Rees, 2018; Shester &
101 Micheli, 2011; Stephenson et al., 2017; Troffe et al. 2005; Walmsley et al., 2015). Impacts
102 from pots may occur during deployment, soak time or hauling of the pot, impacting the
103 benthos and associated taxa through contact with the pot and/or end weight, or from scour
104 caused by the associated ropes.

105

106 Rocky reef habitats are thought to have a medium-high sensitivity to potting impacts and a
107 medium level of resilience (defined as the time required for a habitat (and its constituent
108 species and physical features) to recover to its characteristic state after disturbance), (Eno et
109 al., 2013). Impacts pose a threat in particular to long lived, slow growing sessile epifauna that
110 characterise rocky reef habitats (Coleman et al., 2013; Jennings and Kaiser, 1998; Sheehan et
111 al., 2013b), including species of gorgonian, soft coral, bryozoan and erect branching sponges
112 which are known to be particularly vulnerable due to their erect body-forms, and life histories

113 (Coleman et al., 2013; Langmead et al., 2010). Despite these risks, the impact of pots on
114 benthic marine ecosystems is often regarded as minor in comparison with the impact of
115 mobile benthic gear (Jennings and Kaiser, 1998), and consequently, research efforts have
116 been focussed on the assessment of mobile gear.

117

118 The limited research that has taken place has suggested that whilst some damage does occur
119 it is unlikely to be significant (see Casement and Svane, 1999; Coleman et al., 2013; Eno et al.,
120 2001; Lewis et al., 2009; Shester & Micheli, 2011; Stephenson et al., 2017; Troffe et al. 2005)
121 unless potting intensity is high (defined as ~ 30 pots per 500m^2) where some decline in
122 abundance of indicator species was identified by Rees (2018). The true footprint of potting
123 (contact that the pot makes with the benthos) has not yet been fully quantified, however, and
124 there is a need for more evidence relating to the underwater behaviour and habitat
125 interaction of pots to support these conclusions (Eno et al., 2013; Stephenson et al., 2017).

126

127 Studies suggest that recovery of emergent slow-growing fauna from the impacts of bottom
128 towed fishing gear occurs on decadal timescales (Babcock et al., 1999; Watling and Norse,
129 1998), but that potting activity is unlikely to impede recovery of benthic systems (Blyth et al.,
130 2004; Sheehan et al., 2015; Sheehan et al., 2013b). What is not clear, however, is whether
131 potting activity compromises their ability to reach a fully functional state (Tett et al., 2013) or
132 whether it allows them to meet their ecological goals and achieve favourable conservation
133 status (Jones, 2002). Furthermore, in areas where more destructive fishing practises are
134 restricted, use of static gear may increase (Mangi et al., 2011) and the consequences of this
135 need to be understood.

136

137 The global presence of potting on rocky reefs makes these questions of key importance and
138 more research is required to answer them, particularly in light of the drive for evidence-based
139 policy development and decision making (e.g. Defra, 2011; European Commission, 2015;
140 House of Commons, 2017;), and the requirement to meet international targets for marine
141 conservation. One such target is the Convention on Biological Diversity (CBD) Aichi
142 Biodiversity Target 11 which has resulted in an increasing number of marine protected areas
143 (MPAs) globally (Thomas et al., 2014) and calls to increase protection of each marine habitat
144 from 10-30 % (WCC-2016-Res-050-EN; IUCN WCPA, 2018; IUCN, 2014, 2016; O'Leary et al.,
145 2016) by 2030 (Johnson et al., 2019).

146

147 The requirement to meet these targets increases the likelihood of new MPAs being
148 designated multi-use, and consequently the chance of sites being located on areas of rocky
149 reef where potting occurs. Designation decisions require an ecosystem approach to
150 management to be taken where humans are considered integral to the ecosystem and socio-
151 economic factors are considered alongside ecological (Pikitch et al., 2004; Gaines et al. 2010).
152 As part of these decisions there is also an increasing emphasis on assessing management
153 effectiveness of multi-use sites, with those newly designated designed to include
154 representation targets requiring spatially accurate mapping of habitat types (Day & Dobbs,
155 2013; Johnson et al., 2019; Pomeroy et al., 2005; Garces et al., 2013) in order to avoid the
156 push for meeting targets coming at the expense of the quality and effectiveness of regulation
157 and management (De Santo, 2013). Increasing our knowledge of impacts and their
158 consequences is therefore vital for effective assessment of these sites and ensuring we
159 implement appropriate management measures.

160

161 The aim of this research was therefore to provide robust evidence, which quantified whether
162 the extractive activity of potting is compatible with designation of multi-use MPAs. This was
163 achieved using the Inshore Potting Agreement (IPA) area in South Devon, UK as a test case
164 study site. Unfortunately the nature of human use of the ocean and the relatively recent
165 addition of marine protected areas around the UK coast means that there were no pristine
166 control areas available for this study, hence the following research questions were addressed:
167 (a) is benthic condition and provision of ecosystem services greater in areas within an MPA
168 where trawling has been excluded but potting is permitted than in areas where trawling
169 occurs; (b) what are the mechanisms of physical potting interaction with the benthos and (c)
170 what is the true footprint of potting. For ease of understanding, these are termed (a) benthic
171 condition (b) mechanisms of potting interaction, and (c) true footprint of potting.

172

173 **1.1 Case study site: The Inshore Potting Agreement, South Devon, UK**

174 Although not initially designated this way, the IPA falls under the commonly recognised
175 definition of an MPA (Kelleher 1999) as bottom towed fishing gear was excluded in 1978 from
176 large areas to reduce conflict between mobile and static gear types. This led to the
177 establishment of a zoned fisheries management scheme which was incorporated into
178 statutory legislation in 2002 (Hart et al., 2003) and has provided ecological benefits to areas
179 where bottom towed fishing gear was excluded (Blyth et al., 2004). Furthermore its use aligns
180 with that of IUCN Category VI MPA, which allows the protection of natural ecosystems and
181 sustainable use of natural resources, when conservation and sustainable use can be mutually
182 beneficial (Day et al., 2019). The area is overlain by the Start Point to Plymouth Sound and
183 Eddystone Site of Community Importance (SCI), designated for the protection of reef habitat
184 under the Habitats Directive (Council Directive 92/43/EEC) and from which bottom towed

185 fishing gear was excluded in 2014 (Figure 2), (Natural England, 2013), and overlaps the
186 Skerries Bank and Surrounds Marine Conservation Zone. The presence of the MCZ was not
187 considered during the study as management plans were not yet established.

188

189 The IPA covers an area approximately 500 km² and includes zones where static gear (pots and
190 static nets) is exclusively allowed, areas where towed gear is exclusively allowed and areas
191 where gear types are managed seasonally (Figure 2). The area is managed by the Devon &
192 Severn Inshore Fisheries & Conservation Authority whose remit cover 0-6 nm and who seek
193 to ensure that their management secures the right balance between social, environmental
194 and economic benefits.

195

196 The IPA area is very important both locally and nationally for its brown crab (*C. pagurus*)
197 fishery, with landings from boats into the ports of Dartmouth and Salcombe the largest in
198 England, totalling almost £3.4 million in 2014 (Marine Management Organisation, 2015).
199 Fishers in the area use two different types of pot, inkwell and parlour (see Figure 3). The
200 difference in potential impact of these pot types is unknown, with fishers choosing which to
201 use based on the type of boat they work from and personal preference due to differences in
202 size and shape between the pots (South Devon & Channel Shellfishermen, pers comm.).

203

204 Due to the long history of management within the IPA it is possible to test whether, following
205 approximately 35 years of exclusion of bottom towed fishing gear, the relative health of the
206 ecosystem is greater within the exclusion area than outside where bottom towed fishing gear
207 use continues. In the absence of pristine control sites, this method can help determine
208 whether the presence of potting activity has allowed the ecosystem to recover and deliver

209 more ecosystem services than unprotected areas, or whether potting interactions are
210 compromising benthic rocky reef habitats and the ability of a site to achieve or maintain
211 favourable conservation status (Jones, 2002).

212

213 In the context of this study the term 'relative health' is used due to the absence of data to
214 allow an *a priori* definition of health to be determined. The work of Tett et al. (2013) can be
215 used to develop indicators for the relative health of the ecosystem. The indicators selected
216 included univariate metrics such as number of individuals (individuals m⁻²), number of taxa
217 (taxa m⁻²), diversity (Simpson's 1-λ), number of individuals of selected indicator taxa including
218 *Eunicella verrucosa* and *Pentapora foliacea* which are known to be sensitive to fisheries
219 impacts (individuals m⁻²), and assemblage composition.

220

221 Using the metrics outlined above, the study examined the hypotheses that:

222 (1) Benthic condition:

223 *H1 = number of taxa, number of individuals, diversity and assemblage composition differ*
224 *between potted areas where bottom towed fishing is not permitted and areas open to bottom*
225 *towed fishing*

226 (2) Mechanisms of potting interaction*

227 *H2 = during pot hauls the seabed contact area is smaller than the total possible contact area*
228 *for inkwell and parlour pots*

229 (3) True footprint of potting*

230 *H3 = during pot hauls fewer benthic fauna are damaged or removed than not damaged within*
231 *the seabed contact area for inkwell and parlour pots*

232

233 *Observation of fishing methods and discussion with members of the fishing community in
234 the study area influenced survey design for the mechanisms of potting interaction and true
235 footprint of potting. It may be assumed that a pot will drag constantly across the benthos
236 during the haul, but the uneven topography of a rocky reef area dictates that whilst pots are
237 likely to make some contact the entire base of the pot would not be likely to drag along the
238 benthos; and as such the area of impact (seabed contact area) may be smaller than might
239 initially be assumed (total possible contact area).

240

241 H1 was tested using video footage taken from a towed flying array across ten areas and over
242 three years, and H2 and H3 were tested using video footage taken from cameras mounted on
243 pots for two gear types (parlour and inkwell) across three areas and two years.

244

245 **2. METHODS**

246

247 **2.1 Case study site & survey design**

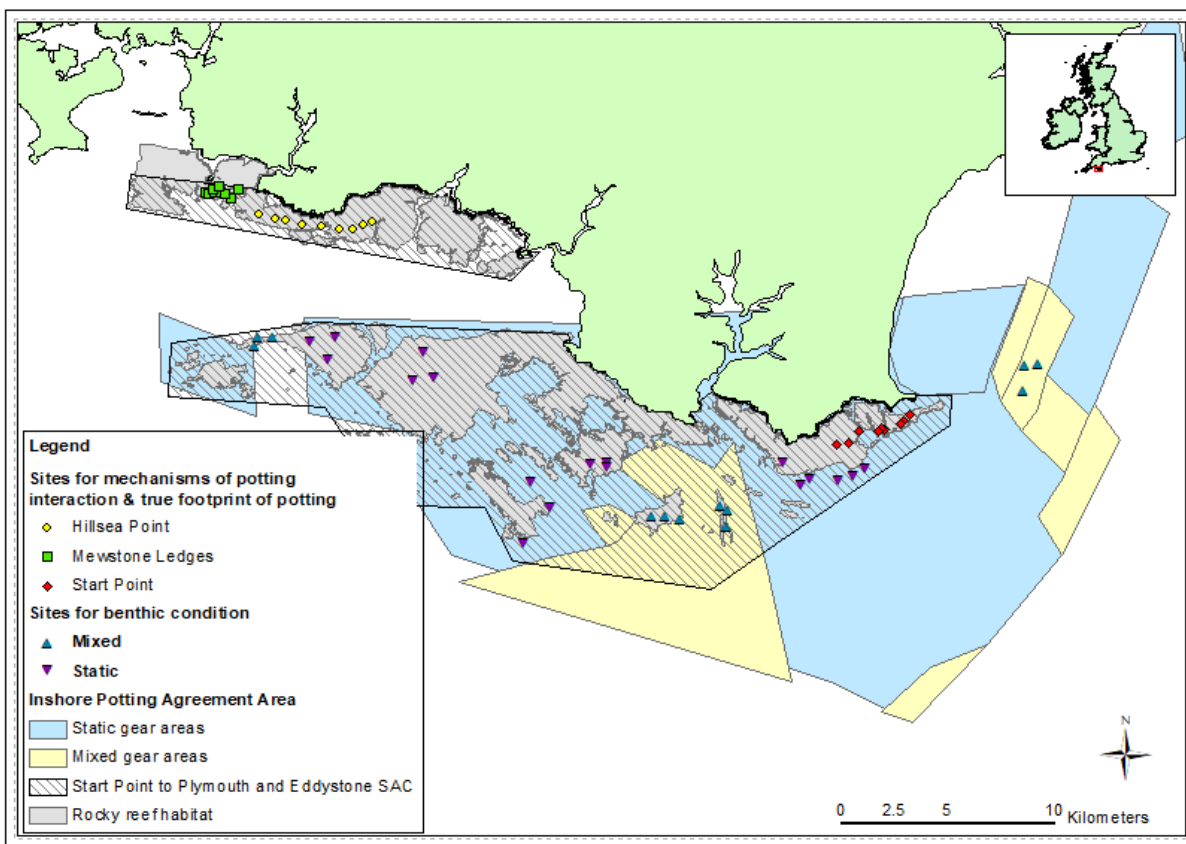
248 The survey was conducted in South Devon UK, in the IPA area, with the majority of sites also
249 within the SCI (Figure 2). Surveys took place on an annual basis over the summer months from
250 2013-2015 for benthic condition and 2014 & 2015 for mechanisms of potting interaction and
251 true footprint of potting.

252

253 The target habitat type was rocky reef as defined by the Habitats Directive as 'habitats where
254 animal and plant communities develop on rock or stable boulders and cobbles' (Jackson &
255 McLeod, 2000). Suitable habitat was identified within the areas overlapping the SCI using
256 sidescan data provided to Devon & Severn IFCA (D&SIFCA) by Cefas, and from a video survey

257 report completed for Natural England (Ross, 2011). In addition, and particularly for the areas
258 outside the SCI where no habit mapping was available, the working knowledge of the fishers
259 and D&SIFCA was used (Figure 2). No data on frequency of fishing activity was available, but
260 potters fish specific areas and there is known to be little space available for additional boats
261 to join the fishery (Blyth et al., 2002; Devon & Severn IFCA, pers. comm.), giving confidence
262 that sites known to be potted would have been regularly fished.

263



264

265 **Figure 2: Survey sites for: benthic condition (Mixed – blue triangles, Static – purple triangles)**
266 **mechanisms of potting interaction & true footprint of potting (Start Point – red circles,**
267 **Hillsea Point – yellow circles, Mewstone Ledges – green squares). Map created using ArcGIS**
268 **2017**

269

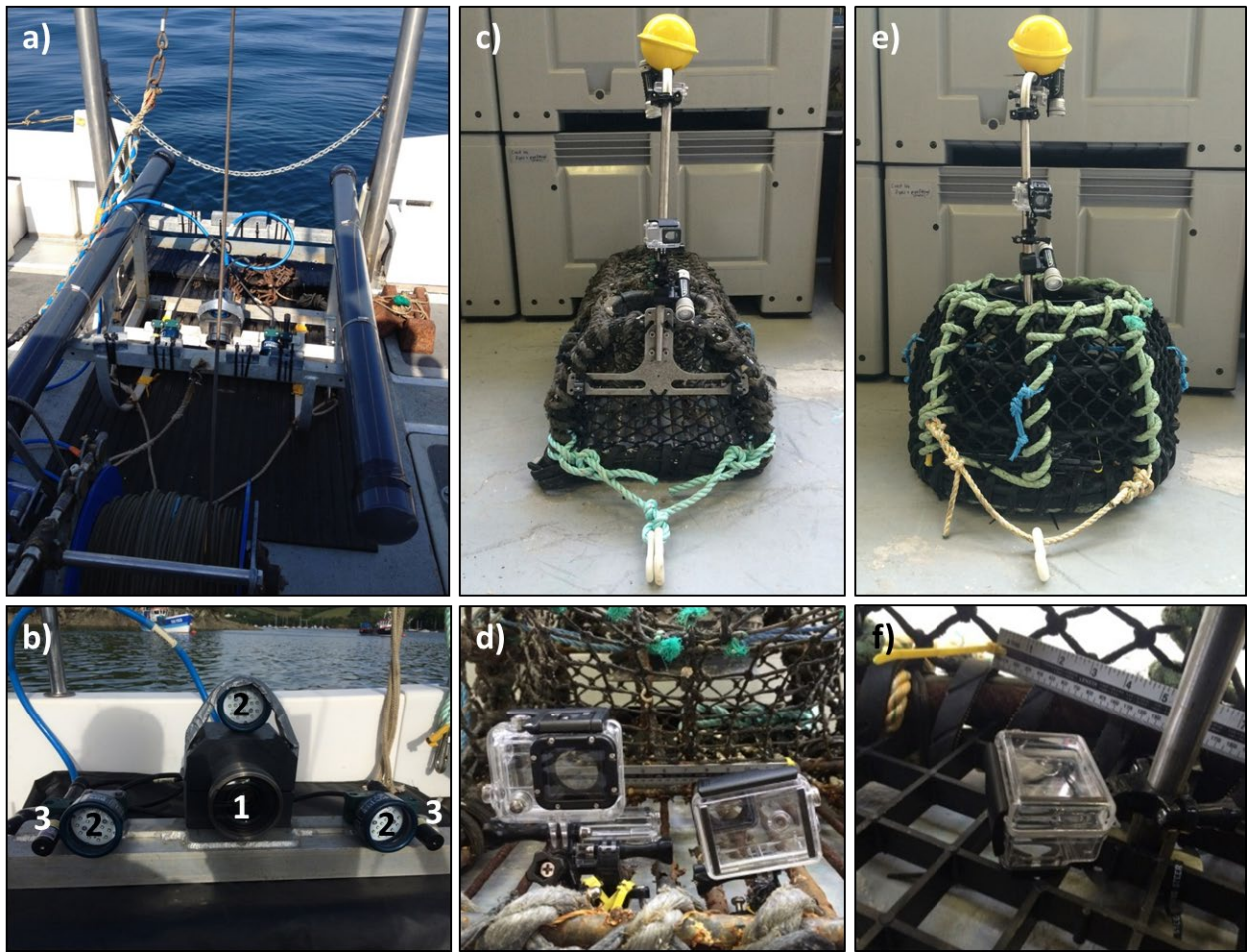
270 2.2 Benthic condition

271 Two treatments were selected, “Static” where only static gear (mainly pots) had been fished
272 since the IPA was established in 1978, and “Mixed”, where areas are open to both mobile and
273 static gear (only one area was open to mobile gear alone and did not provide enough suitable
274 habitat type). A total of 30 sites were sampled at a target depth of 50 m, and were distributed
275 across the survey area in groups of three “Locations” (A-J see Figure 2) to account for any
276 effects resulting from the known differences in topography and exposure to tidal streams.
277 Eighteen sites were sampled in the Static treatment, and 12 in the Mixed (Figure 2). At each
278 site a 20-minute video transect was recorded to sample sessile and sedentary taxa using a
279 High Definition camera mounted on a flying array towed behind the boat at a speed of
280 approximately 0.4 knots, equating to approximately 200 m per tow (Figure 3). The method
281 followed that developed by Sheehan et al. (2010) to ensure that sampling was cost-effective,
282 relatively non-destructive and to minimise the risk of snagging on uneven rocky reef or
283 boulders (Sheehan et al., 2016).

284

285 Sampling aimed to quantify differences in the univariate metrics: number of individuals (m^{-2}),
286 number of taxa (m^{-2}), diversity (Simpson’s $1-\lambda$) and a number of selected indicator taxa (m^{-2}),
287 namely *Alcyonidium diaphanum*, *Alcyonium digitatum*, branching sponges, *Cliona celata*,
288 *Eunicella verrucosa*, *Metridium senile*, *Pentapora foliacea* and *Urticina felina*, plus the
289 multivariate metric assemblage composition. Indicator taxa were those expected to be
290 susceptible to damage from fishing impacts (Coleman et al., 2013; Langmead et al., 2010) and
291 were selected based on life history, tolerance to disturbance and recoverability, following
292 Jackson et al. (2008) and Langmead et al. (2010).

293



294

295 **Figure 3: a) flying array on deck, b) flying array HD camera (1), LED lights (2) and lasers (3),**
 296 **c) set up of GoPro cameras mounted on a parlour pot d) back view camera (left hand side)**
 297 **and the inside view camera (right hand side), e) set up of GoPro cameras mounted on an**
 298 **inkwell pot, and f) the down view camera**

299

300

301 **2.2.1 Field methods**

302 The video system included a HD camera (Bowtech Products Limited, Surveyor-HD High

303 Definition Underwater Colour Zoom Video Camera, 720p), LED lights (Bowtech Products

304 Limited, LED-K-Series Underwater LED Light), and two laser pointers to allow the field of view

305 to be calibrated (Apinex Inc. BALP-LG05-B105). The camera was positioned at an oblique angle

306 to the seabed with the LED lights mounted on either side and above the camera, and the

307 lasers fixed outside of the lights 30 cm apart (Figure 3). The camera was connected via an

308 umbilical to a Bowtech System power and control unit, which gave topside control of the
309 focus, zoom and aperture of the camera and the intensity of the lights.

310

311 **2.2.2 Video analysis**

312 Data were extracted by examination of individual HD video frames taken at two second
313 intervals to avoid overlap using 3Dive Frame Extraction software (Cybertronix). Images were
314 overlain with a 0.25 m² counting grid calibrated using the position of the lasers which allowed
315 extraction of density and percentage cover information for each taxon. Strict criteria were
316 adhered to during the selection of frame grabs suitable for analysis following methods
317 developed by Sheehan et al., (2013b) and Stevens et al. (2014), and only those where the
318 habitat fitted the definition of a rocky reef (Jackson & McLeod, 2000) were included. Once
319 those suitable for analysis were finalised, 30 frame grabs were randomly selected for analysis
320 (Stevens et al., 2014). Data were averaged by transect prior to analysis to avoid pseudo-
321 replication.

322

323 All taxa present in each frame were identified to the lowest taxonomic level possible. Number
324 of individuals was enumerated using count (ind. m⁻²) or cover (% m⁻²) as appropriate.
325 Taxonomically similar species that could not be distinguished with confidence, such as
326 branching sponges or hydroids, were grouped to ensure confidence in the data recorded.

327

328 **2.2.3 Data analysis**

329 Multivariate and univariate analyses were conducted using Permutational Multivariate
330 Analysis of Variance (PERMANOVA, Anderson (2001); Clarke and Warwick (2001)) based on
331 similarity matrices using PERMANOVA+ for Primer in PRIMER 6 (Clarke and Warwick, 2001).

332 Multivariate data were dispersion weighted and fourth root transformed to down weight
333 species with large or erratic abundances and allow rarer species to contribute to the outcome
334 (Clarke et al., 2006). Bray-Curtis similarity indices were used to construct similarity matrices.
335 Univariate data were also fourth root transformed and Euclidean dissimilarity indices were
336 used to construct similarity matrices (Clarke and Warwick, 2001). Each term in the analyses
337 used 9999 permutations of the appropriate units (Anderson and Braak, 2003).

338

339 Four factors were used in the analyses, Year (random: 2013, 2014, 2015), Treatment (fixed:
340 Static, Mixed), Location (random and nested in Treatment: 6 Static, 4 Mixed) and Site (random,
341 nested in Location: 3 per Location). The lowest significant effect was interpreted for each test
342 ($P < 0.05$) and significant interactions involving fixed factors were interpreted using pairwise
343 tests. Data were visualised using Non-metric Multi-Dimensional Scaling (nMDS) with vectors
344 overlain showing key SIMPER results.

345

346 **2.3 Mechanisms of potting interaction and true footprint of potting**

347 A total of 27 sites were selected, in three areas, Start Point (SP), Mewstone Ledges (ML) and
348 Hillsea Point (HP), (Figure 2). At each site, one string of inkwell pots and one string of parlour
349 pots were deployed approximately 200 m apart, with four pots per string, and GoPro Hero 2,
350 3 and 4 Silver and Black edition (GoPro Inc) cameras fitted to alternate pots. Each camera pot
351 had 5 cameras mounted to give: (a) a bird's eye view over the pot; (b) an inside view from
352 within the pot; (c) a downwards view through the base of the pot (d) a rope view of where
353 the rope connecting the pot attached (e) a backwards view at the opposite end to where the
354 rope attaches to the pot to show the ground the pot was being hauled over (Figure 3). Surveys
355 were conducted from commercial fishing vessels to ensure that pot deployment and hauling

356 was representative of true fishing conditions (for detailed descriptions of how this was
357 conducted, please see Supplementary Material).

358

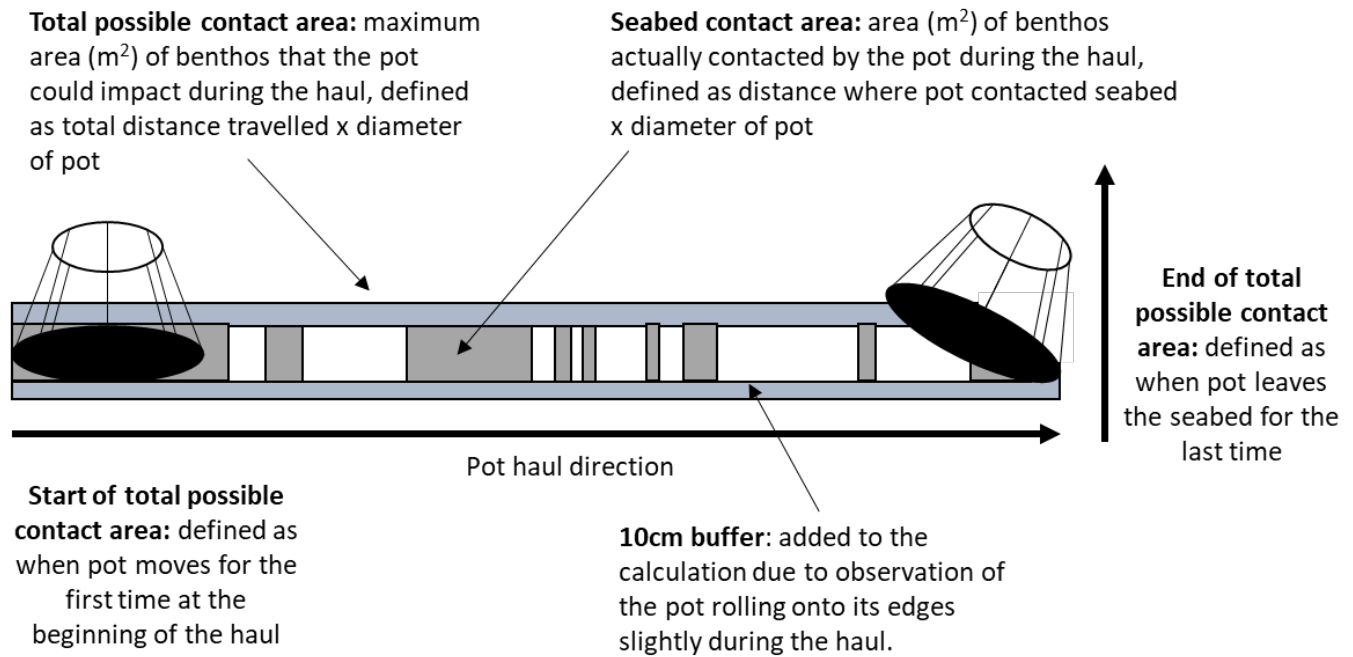
359 As discussed, the uneven topography of a rocky reef area dictates that pots are likely to make
360 some contact but that the entire base of the pot would not be likely to drag along the benthos
361 during hauling; and as such the area of impact (seabed contact area) may be smaller than
362 might initially be assumed (total possible contact area). Estimation of impact based on length
363 of total possible contact area would therefore result in an overestimation.

364

365 Sampling aimed to quantify the mechanisms of potting interaction and the true footprint of
366 a pot through quantification of: settle duration (seconds from point of first contact to
367 becoming stationary) pot stability during the soak, haul duration (seconds from first
368 movement to clearing the reef), total possible contact area (defined as total distance travelled
369 x area of base of pot (m^2)) and seabed contact area (defined as distance where pot contacted
370 seabed x area of base of pot (m^2)), (see Figure 4). The start and end GPS position of the haul
371 were unknown. To estimate the length of each tow the known pot dimensions were used as
372 a reference to visually assess how much distance was covered by each pot. Videos were
373 played x2 slower than real-time to aid this assessment.

374

375 In addition, biotic metrics were also used: number of individuals ((not damaged, damaged,
376 removed), (number of individuals m^{-2})), and for selected indicator taxa known to be sensitive
377 to fishing impact (Coleman et al., 2013; Jackson et al., 2008; Langmead et al., 2010),
378 *Alcyonium digitatum*, branching sponges, *Cliona celata*, *Eunicella verrucosa* and *Pentapora*
379 *foliacea*, number of individuals ((not damaged, damaged, removed), (m^{-2})) was also calculated.



380

381 **Figure 4: Diagrammatic example of how the total possible contact area and seabed contact**
 382 **area were calculated during the pot haul**

383

384 The strings of pots were set as they would be under normal fishing conditions, in
 385 approximately 30 m of water. End weights were used to anchor each end of the string, and a
 386 leaded line joined the string to the buoy on the surface. Leaded line was also used between
 387 the pots, which were deployed for 25 minutes, allowing sufficient time to settle, and were
 388 then hauled and redeployed at the next site.

389

390 All cameras were set to record in the 1080p, 30 frames per second mode, giving high quality
 391 footage while conserving battery life. Two Underwater Kinetics Aqualite torches were also
 392 mounted on each pot, one under the rope view camera and the other by the bird's eye camera
 393 to counteract poor light conditions (Figure 3).

394

395 **2.3.1 Video analysis**

396 Despite having five cameras mounted on the pots, it became apparent that all metrics except
397 for the rope movement were best quantified using the video from the bird's eye camera. The
398 rope view camera was used for assessing rope movement. Whilst the other three cameras
399 provided useful observational information and contributed to the understanding of the pot
400 movements and impacts, they were not used for data analysis. The greatest constraint on the
401 survey was the battery life of the GoPro cameras and on the few occasions where they did
402 not last for the full haul the data were excluded from the analysis.

403

404 **2.3.1.1 Mechanisms of potting interaction**

405 HD video was watched from each camera view for each haul, and data were extracted for
406 each metric (for details see section 2.3). A 10 cm buffer was added to the pot area to calculate
407 the total possible contact area and seabed contact areas as video analysis revealed that pots
408 were often unstable as they moved across the ground during the haul, resulting in some slight
409 rolling onto their sides (Figure 4). The seabed contact area is therefore expected to be a
410 calculation of maximum impact.

411

412 **2.3.1.2 True footprint of potting**

413 Taxa were identified to the highest taxonomic level possible, although taxonomically similar
414 species were grouped to avoid misidentification, with groupings as stated in benthic condition.
415 Hauls were conducted at a relatively constant speed so video quality was consistent and only
416 those species for which a positive ID could be made with confidence were included in the
417 analysis. Description of taxon damage is given in Table 4, where 'abrasion' is visible rubbing
418 commonly resulting in clouding of the water suggesting tissue removal, and 'sections

419 removed' where injury occurred resulting in clouding of the water and the presence of small
420 sections of tissue in the water column. The implications of these were considered comparable
421 and the definitions apply to interactions from both the pots and the ropes.

422

423 **2.3.2 Statistical analysis**

424 Data were pooled per string (two pots) and multivariate and univariate analyses were
425 conducted for data on seabed contact area and number of individuals using Permutational
426 Multivariate Analysis of Variance (PERMANOVA+, (Anderson, 2001; Clarke and Warwick,
427 2001)) based on similarity matrices using PERMANOVA+ for Primer in PRIMER 6 (Clarke and
428 Warwick, 2001). Multivariate data were square root transformed and Bray Curtis similarity
429 indices were used to construct similarity matrices. Univariate data were untransformed and
430 Euclidean dissimilarity indices were used to conduct similarity matrices (Clarke and Warwick,
431 2001). Each term in the analyses used 9999 permutations of the appropriate units (Anderson
432 and Braak, 2003).

433

434 Three random factors, Year (2014, 2015), Location (Start Point (SP), Mewstone Ledges (ML),
435 Hillsea Point (HP)), and Site (1-9 nested in Location) and one fixed factor Pot Type (Parlour (P),
436 Inkwell (I)) were used in the analysis. To test whether the number of individuals not damaged
437 was significantly greater than the number of individuals damaged or removed, a repeated
438 measures approach to ANOVA was used with the additional random factor Pot haul path (1-
439 102), nested in Year, Pot type and Site (added as the measures of individuals not damaged,
440 damaged and removed were taken from the same pot haul path for each haul (Bob Clarke,
441 pers. comm.)), and the fixed factor Response (No Damage (ND), Damaged (D) and Removed

442 (R). The lowest significant effect was interpreted for each test ($P < 0.05$) and significant
443 interactions involving fixed factors were interpreted using pairwise tests.

444

445 **2.3.3 Effect size analysis**

446 In addition to the statistical testing, effect size was also calculated on un-pooled data to allow
447 further examination of the impacts of potting and the differences between the two pot types.

448

449 **2.3.3.1 Mechanisms of potting interaction**

450 For each pot haul, the strip length (total distance moved during the haul) was estimated from
451 the video using visual reference points on the seabed. Seabed contact area was estimated as
452 the number of pot lengths where the pot was in contact with the seabed, multiplied by the
453 footprint of the pot.

454

455 Seabed contact area and strip length (total distance (m) moved during the haul; note this
456 differs from total possible contact area (m^2)) were calculated for each pot. The effect of strip
457 length, pot type (fixed factors), location and year of sampling (random factors), and their
458 interactions on seabed contact area was tested using linear models in the software package
459 R (R Core Team 2019) with the lme4 package (Bates et al., 2015). Overall effects of the two
460 pot types were calculated as mean contact areas and (95 %) confidence intervals using the
461 package emmeans (Lenth 2019).

462

463 **2.3.3.2 True footprint of potting**

464 The effect of pot hauling on benthic fauna was explored for the identified assemblage, and
465 for species grouped according to body type (erect-emergent and low-encrusting) based on

466 the BIOTIC database (MarLIN, 2006) for each species or its closest available relative. Species
467 were quantified in terms of abundance not damaged, damaged or removed. For pot-level
468 observations, the mean value of species responses was calculated for each pot, before
469 estimating effect sizes and confidence intervals. For body type statistics, abundances were
470 calculated for each species, then a mean for each body type within each pot was calculated,
471 before calculation of mean effects and confidence intervals. Mobile benthic species were
472 omitted from this analysis owing to only one record of damage.

473

474 Effects were calculated as fractions of fauna removed, damaged or undamaged by the two
475 different pot types, with overall mean fractions and 95 % confidence intervals calculated using
476 a nonparametric bootstrap method from the Hmisc package (Harrell, 2019). Responses were
477 compared between pot types using Wilcoxon-Mann-Whitney tests in the R package coin
478 (Hothorn et al., 2008), and effect sizes calculated as Wilcoxon r values using the R package
479 rstatix (Kassambara 2020).

480

481 **3. RESULTS**

482

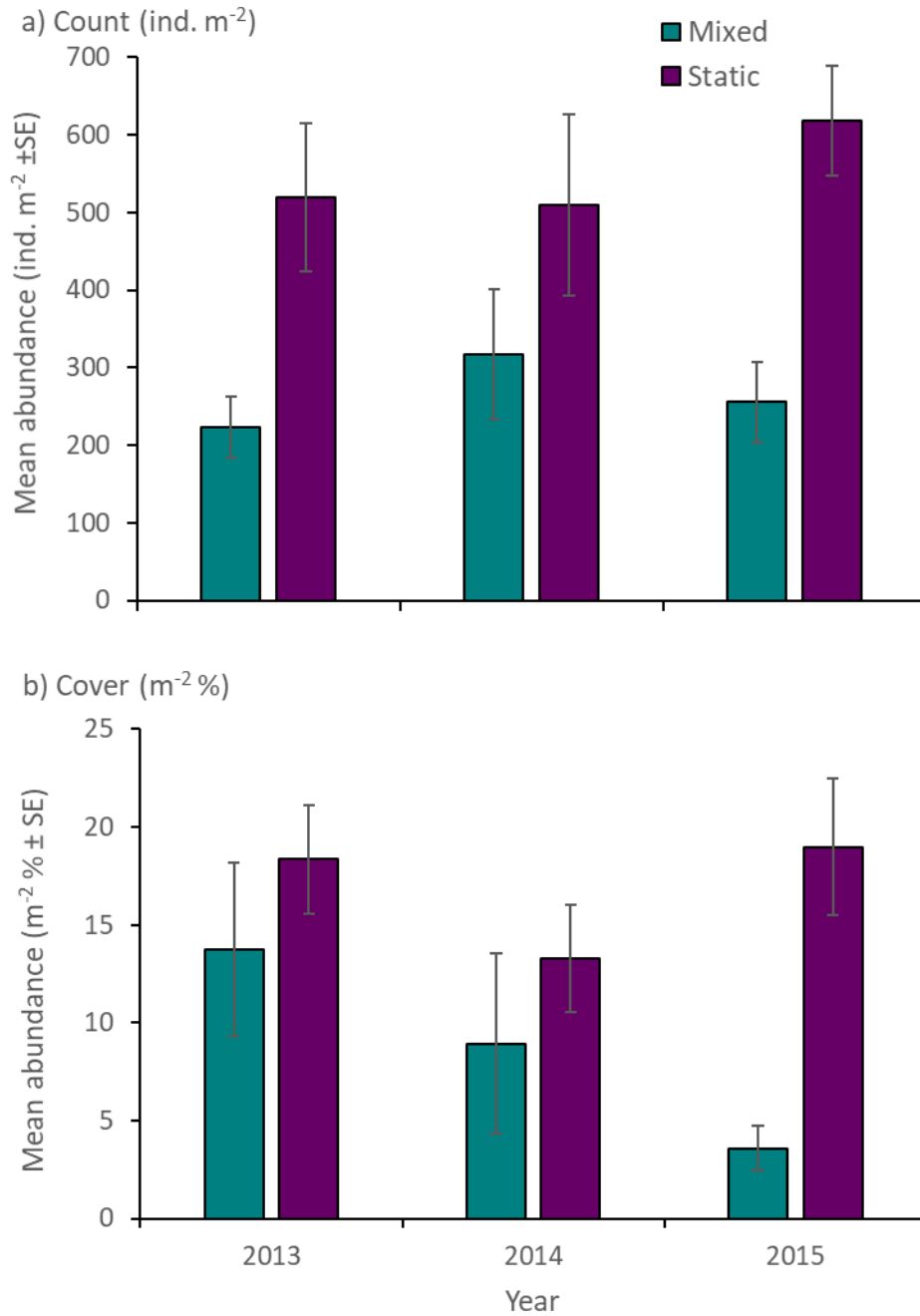
483 When interpreting the results, the phrasing 'significantly greater' has been used where there
484 is statistical significance ($p < 0.05$). Where the phrase 'consistently greater' is used there has
485 not been a statistical significance identified, but highlighting the trends seen was felt to be of
486 importance. All significant interactions are reported below. Full PERMANOVA tables and
487 results from linear modelling and effect size analyses can be found in the supplementary
488 material (Tables S1-S10).

489

490 **3.1 Benthic condition**

491 A total of 91 taxa were recorded from eight phyla. A significant Treatment effect was
492 identified for the abundance of “cover” individuals ($p < 0.05$), with abundance significantly
493 greater in the Static than Mixed treatment (Static = $16.88 \text{ m}^{-2} \% \pm 1.75$, Mixed = $8.73 \text{ m}^{-2} \% \pm$
494 2.16 ; Figure 5). Abundance of “count individuals”, number of taxa and diversity was also
495 consistently greater in the Static than the Mixed treatment (Count: Static = $549.41 \text{ ind. m}^{-2} \pm$
496 54.86 , Mixed = $260.45 \text{ ind. m}^{-2} \pm 16.24$; Number of taxa: Static = $20.37 \text{ m}^{-2} \pm 0.35$, Mixed =
497 $17.00 \text{ m}^{-2} \pm 0.49$; Diversity: Static = 0.54 ± 0.01 , Mixed = 0.49 ± 0.02 ; Figure 5), although no
498 Treatment effect was identified.

499



500

501 **Figure 5: Mean abundance of all a) Count (individuals m⁻² ± SE) and b) Cover (m⁻² % ± SE)**
 502 **individuals in the Static and Mixed treatments per year (2013, 2014, 2015)**

503

504 Despite significant temporal and spatial variation, a significant treatment effect was identified
 505 for assemblage composition, with two distinct groupings apparent (P < 0.05, Table 1, Figure

506 6): despite some overlap, sites in the static treatment were more similar to each other than
 507 to the sites in the mixed treatment.

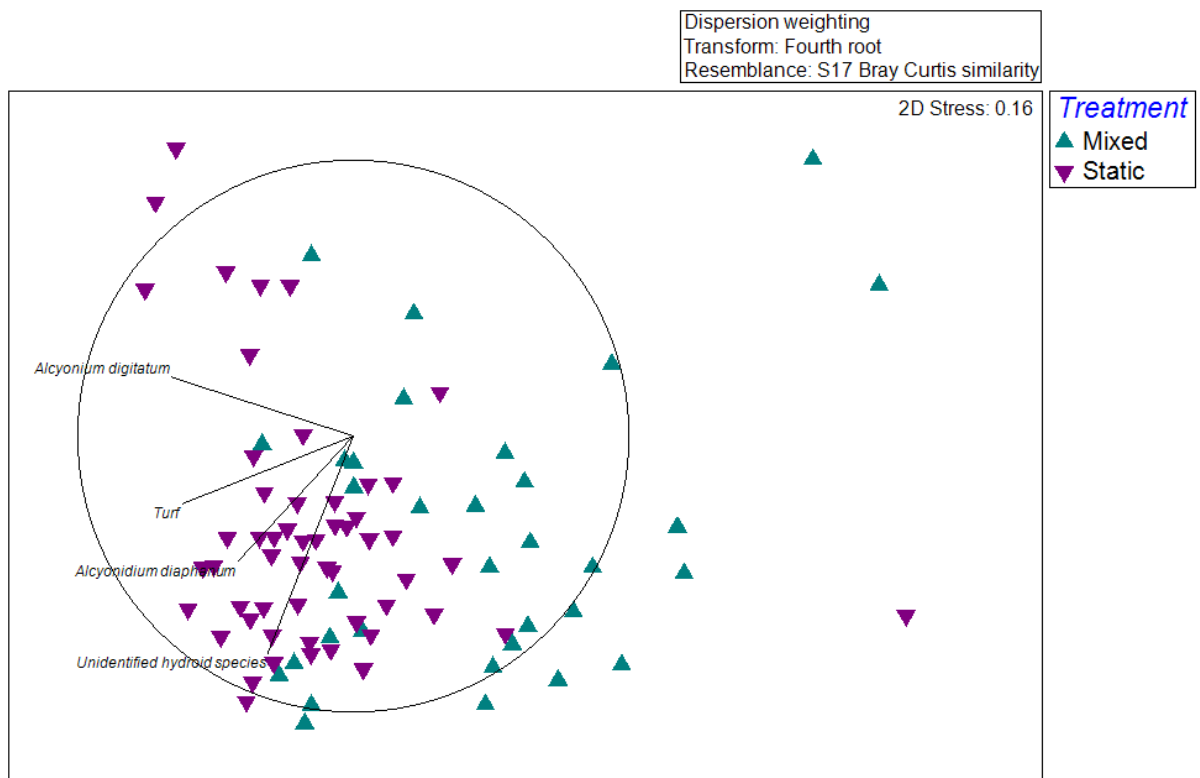
Source	df			
		MS	Pseudo-F	P(perm)
Year	2	3812.80	3.16	0.0002
Treatment	1	13717.00	1.82	0.04
Location(Treatment)	8	6373.50	2.80	0.0001
Year x Treatment	2	1833.80	1.55	0.07
Site(Location(Treatment))	20	1326.90	1.68	0.0001
Year x Location(Treatment)	16	1178.60	1.50	0.0004
Res	37	787.55		
Total	86			

508

509 **Table 1: PERMANOVA to test the differences in assemblage composition between Years**
 510 **(2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and**
 511 **Treatments (Static, Mixed). Data were dispersion weighted and fourth root transformed**
 512 **prior to the construction of a Bray Curtis resemblance matrix. Bold values indicate**
 513 **significant differences.**

514

515



516

517 **Figure 6: nMDS ordination illustrating similarities in assemblage composition between**
 518 **Treatments. Vectors show key species driving differences as identified through SIMPER**

519

520 Results of SIMPER (Table S4; Supplementary material) showed the distinction between
521 Treatments was driven primarily by differences in the abundance of hydroid and bryozoan
522 turf, *A. digitum*, hydroids, and *Alcyonidium diaphanum* (Figure 6; cumulative contribution =
523 34.10 %). Abundance was greatest in the Static treatment for all but one indicator, *M. senile*
524 (Table S4; Supplementary material). Treatment effects were identified for *A. digitatum*, *C.*
525 *celata* and *M. senile* and as with assemblage composition some variation was observed
526 between random factors for most indicators.

527

528 **3.2 Mechanisms of potting interaction**

529 Pots took an average of 3.46 seconds (± 0.27) to settle (from first touch to stationary), with
530 Inkwell pots taking 3.29 seconds (± 0.35) and Parlour pots taking 3.63 seconds (± 0.42). The
531 majority of pots (82.5 %) landed upright, with more parlour than inkwell pots landing on end
532 (Parlour = 17.82 %, Inkwell = 4.04 %), as would be expected due to their design. Pots were
533 relatively stable (no movement = 86.36 % of soaks), although movement did occur in some
534 instances (some occasional movements = 8.08 % of soaks; small movements throughout soak
535 = 4.04 %; large movements throughout the soak = 1.52 % of soaks).

536

537 The pots took 41 seconds (± 3.24) to haul (from first movement to clearing the seabed for
538 good). The total time that the pots moved across the seabed (rather than being stationary or
539 off the seabed), however, was 20.71 seconds (± 1.36), meaning that they were in contact with
540 the seabed for approximately half the time it took for them to be lifted clear. Rope movement
541 during the soak was observed for 51.02 % of soaks, although 45.91 % of the time this
542 movement was described as minimal, where the rope moved slightly with the tide but no
543 scour or species impacts were observed.

544 **3.2.1 Seabed contact area**

545 The total possible contact area (total distance travelled x area of base of pot) was $6.20 \text{ m}^2 \pm$
 546 0.61 , and the length of the seabed contact area (distance where pot contacted seabed x area
 547 of base of pot) was $3.04 \text{ m}^2 \pm 0.24$ (49.07 % of the total possible contact area).

548

549 Differences between pot types were apparent with a significant Pot x Site(Location)
 550 interaction identified; total possible contact areas were significantly larger than seabed
 551 contact areas for both pot types, and were larger for inkwell pots than for parlour pots
 552 (inkwell, total possible contact area = $7.16 \text{ m}^2 \pm 1.00$, seabed contact area = $3.51 \text{ m}^2 \pm 0.40$,
 553 parlour, total possible contact area = $5.24 \text{ m}^2 \pm 0.67$, seabed contact area = $2.57 \text{ m}^2 \pm 0.24$, P
 554 < 0.05 ; Table 2). These trends were consistent between Areas.

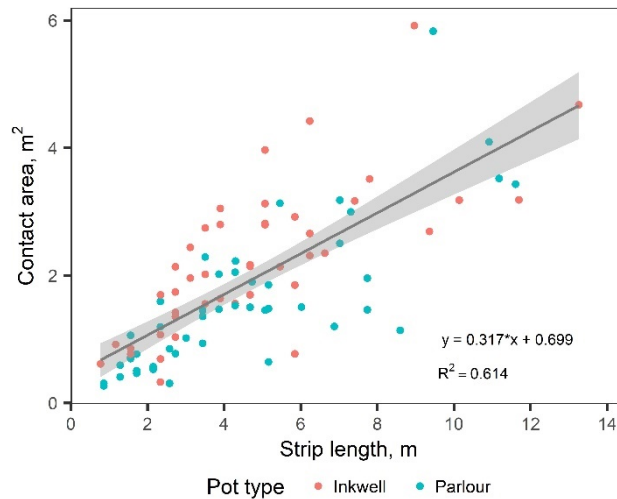
555

556 **Table 2: Mean, N, standard error (SE), minimum (Min) and maximum (Max) values for**
 557 **seabed and total possible contact area by pot type (Inkwell and Parlour)**

	Mean	N	SE	Min	Max
<i>Seabed contact area</i>					
Inkwell	3.51	54.00	0.40	0.00	15.56
Parlour	2.57	54.00	0.24	0.00	7.16
<i>Total possible contact area</i>					
Inkwell	7.16	54.00	1.00	0.00	27.45
Parlour	5.24	54.00	0.67	0.00	24.26

558

559 Linear modelling indicated mean seabed contact areas varied by pot type and strip length
 560 ($F_{2,91} = 74.9$, $p < 0.0001$) (Supplementary Material, Table S6), increasing linearly with strip
 561 length (Figure 7). This pattern was consistent between pot types, with no significant
 562 interaction between strip length and pot type. For completeness, pot-specific relationships
 563 between strip length and contact area are presented in the Supplementary Material (Table
 564 S7).



566

567 **Figure 7: Contact area of pots during hauling as a function of distance travelled during the haul (strip length), for the two pot types, Inkwell (red) and Parlour (blue). Linear model fit**
 568 **and 95 % confidence interval overlaid.**

569

570 **3.3 True footprint of potting**

572 A total of 18 taxa were identified from the videos (Table 4), from six phyla. Abundance across
 573 all sites was greatest for the solitary baked bean ascidian *Dendrodoa grossularia* (8.46 ind. m⁻²
 574 ± 2.95), macroalgae (2.20 ind. m⁻² ± 0.40) and the soft coral *A. digitatum* (1.75 ind. m⁻² ±
 575 0.28), (Table 4).

Species name	Common name	Phylum	Damage description	Total	Inkwell			Parlour		
					ND	D	R	ND	D	R
<i>Alcyonidium diaphanum</i>	Sea chervil	Bryozoa	Abrasion	0.33 ± 0.11	68.72	31.28	0.00	71.66	27.77	0.57
* <i>Alcyonidium digitatum</i>	Dead Man's Fingers	Cnidaria	Abrasion and/or sections removed	1.75 ± 0.28	63.76	26.63	9.60	66.87	21.05	12.09
<i>Asterias rubens</i>	Common starfish	Echinodermata	None	0.11 ± 0.03	100.00	0.00	0.00	100.00	0.00	0.00
	*Branching sponges	Porifera	Abrasion and/or sections removed	0.18 ± 0.06	50.59	49.41	0.00	83.52	16.48	0.00
* <i>Cliona celata</i>	Boring sponges	Porifera	Abrasion and/or sections removed	0.10 ± 0.02	44.58	54.26	1.16	76.48	22.23	1.29
<i>Dendrodoa grossularia</i>	Baked bean ascidian	Chordata	Abrasion	8.46 ± 2.95	61.97	37.90	0.13	66.38	31.42	2.20
<i>Diazona violacea</i>	Football ascidian	Chordata	None	0.003 ± 0.002	0.00	0.00	0.00	100.00	0.00	0.00
<i>Echinus esculentus</i>	Edible sea urchin	Echinodermata	None	0.03 ± 0.01	100.00	0.00	0.00	100.00	0.00	0.00
* <i>Eunicella verrucosa</i>	Pink sea fan	Cnidaria	Abrasion	0.12 ± 0.03	44.96	55.04	0.00	64.62	35.38	0.00
<i>Flustra foliacea</i>	Bryozoans	Bryozoa	Abrasion and/or sections removed	0.22 ± 0.10	57.85	42.15	0.00	68.49	31.51	0.00
<i>Gymnangium montagui</i>	Yellow feathers	Cnidaria	Abrasion and/or sections removed	0.005 ± 0.005	0.00	0.00	0.00	0.00	100.00	0.00
<i>Holothuria forskali</i>	Cotton spinner	Echinodermata	None	0.09 ± 0.02	100.00	0.00	0.00	100.00	0.00	0.00
<i>Laminaria digitata</i>	Kelp		Abrasion and/or sections removed	0.003 ± 0.003	80.00	20.00	0.00	0.00	0.00	0.00
	Macroalgae		Abrasion and/or sections removed	2.20 ± 0.10	71.69	27.26	1.05	90.34	9.66	0.00
<i>Marthasterias glacialis</i>	Spiny starfish	Echinodermata	Abrasion and/or damage to a leg	0.26 ± 0.04	100.00	0.00	0.00	97.70	2.30	0.00
	Massive sponges	Porifera	Abrasion and/or sections removed	0.13 ± 0.04	65.50	34.50	0.00	74.80	25.20	0.00
<i>Nemertesia antennina</i>	Sea beard	Cnidaria	Abrasion and/or sections removed	0.23 ± 0.09	86.59	13.41	0.00	83.54	16.46	0.00
* <i>Pentapora fascialis</i>	Ross coral	Bryozoa	Abrasion and/or sections removed	0.07 ± 0.02	13.39	82.13	4.49	60.83	36.95	2.23

576

577 **Table 4: Description of the damage caused to the taxa present in the pot haul path, mean**
 578 **number of individuals (individuals m⁻²) and percentage of individuals (individuals m⁻²) Not**
 579 **Damaged (ND), Damaged (D) and Removed (R) during the haul. An asterisk (*) denotes**
 580 **indicator taxa.**

581 Of the 18 taxa identified, 14 suffered damage from pot impacts, including all five indicator
 582 taxa, and individuals of six taxa were removed from the reef, including three indicator taxa
 583 (Table 4). Pot hauling damaged or removed between 25 and 30 % of observed epibenthic
 584 species recorded by the pot-mounted cameras (Table 5), with broadly consistent patterns
 585 between pot types for all responses ($p > 0.05$), and small effect sizes (Wilcoxon r) of 0.124 and
 586 0.127, and 0.006 for the responses Not Damaged, Damaged, and Removed, respectively.

587
 588 **Table 5: Pot-level effects. Mean fraction of all species abundance responses to pot hauls for**
 589 **Inkwell (n = 45) and Parlour (n = 46), 95 % confidence intervals (CI) and standard error (SE)**
 590

Pot type	Response	Mean fraction	Lower CI	Upper CI	SE
Inkwell	Not Damaged	0.697	0.629	0.769	0.035
	Damaged	0.282	0.214	0.350	0.037
	Removed	0.021	0.011	0.035	0.006
Parlour	Not Damaged	0.754	0.696	0.803	0.029
	Damaged	0.217	0.168	0.275	0.027
	Removed	0.029	0.014	0.049	0.009

591

592 3.3.1 Species specific responses

593 Only four species suffered no damage or removal from potting activity; individuals of *Echinus*
 594 *esculentus*, *Holothuria forskali* and *Asterias rubens* were observed to roll (*E. esculentus*) or be
 595 moved out of the way by the pressure wave from a pot. No damage was observed suggesting
 596 they may be able to withstand the gentle movement caused. During the survey no instances
 597 of direct impact were observed, however.

598

599 In four of the five instances where rope movement occurred, the rope was in full contact with
 600 the substratum; impact was, however, limited to abrasion of *A. digitatum* and *E. verrucosa*.
 601 Five instances occurred where damage was evident from rope contact during the haul,

602 including four occasions (3.70 % of hauls) where rope caught on *A. digitatum* causing abrasion
603 and the removal of two individuals from the reef.

604

605 The mean number of individuals (all taxa) was $0.79 \text{ ind. m}^{-2} \pm 0.17$. A significant Year x Location
606 x Response interaction was identified, and despite some spatial variation there were
607 significantly more individuals not damaged ($0.54 \text{ ind. m}^{-2} \pm 0.05$ (68.35 %)) than damaged
608 ($0.23 \text{ ind. m}^{-2} \pm 0.03$ (29.11 %)), not damaged than removed (removed = $0.02 \text{ ind. m}^{-2} \pm 0.00$
609 (2.53 %)) and damaged than removed.

610

611 There were four taxa for which more individuals were more damaged than not damaged,
612 three of which were indicator species; (Inkwell pots: *C. celata* (D = 54.26 %, ND = 44.58 %), *E.*
613 *verrucosa* (D = 54.04 %, ND = 44.96 %) and *P. foliacea* (D = 82.13 %, ND = 13.39 %); Parlour
614 pots *Gymnangium montagui* (D = 100 %, although only one colony was observed during the
615 study and this was damaged by a parlour pot haul)).

616

617 The taxa removed from the reef included two upright, branching taxa, *Alcyonidium*
618 *diaphanum* and *A. digitatum*, two taxa with massive forms projecting from the reef, *C. celata*
619 and *P. foliacea*, *D. grossularia* which attaches to the reef at its base and has a lifespan of 1-2
620 years (MarLIN, 2006) and macroalgae which was observed in dense clumps at some sites and
621 whose growth is annual.

622

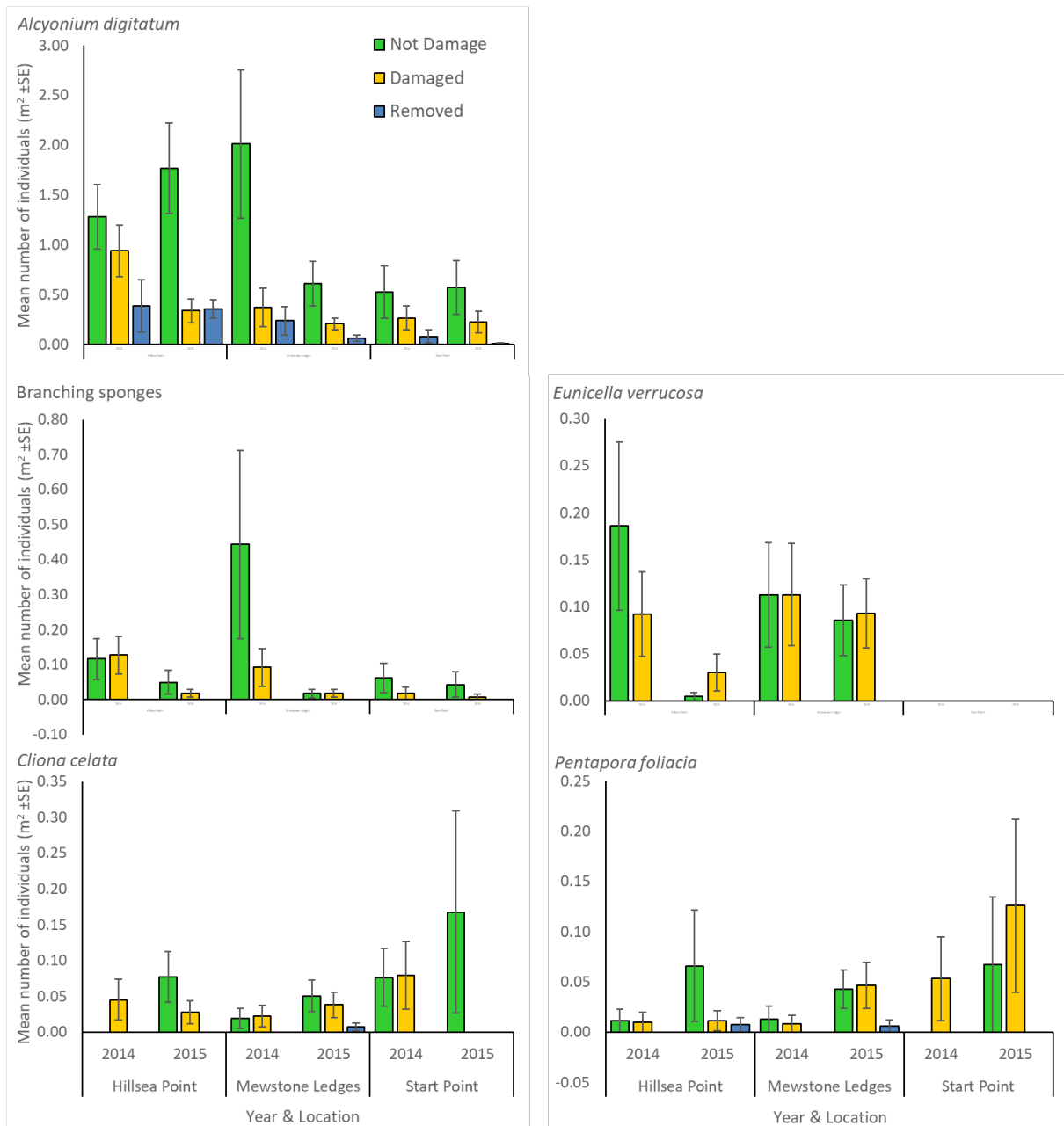
623 **3.3.2 Indicator taxa responses**

624 The most abundant indicator taxon was *A. digitatum* ($1.15 \text{ ind. m}^{-2} \pm 0.18$) and the least
625 abundant was *P. foliacea* ($0.03 \pm 0.01 \text{ m}^{-2}$) but abundance varied between sites and years for

626 all species (Figure 8). All indicator taxa were damaged during the haul, but only individuals of
627 *A. digitatum*, *C. celata* and *P. foliacea* were removed (Table 4, Figure 8). A significant Pot Type
628 x Site(Location) interaction was identified for the response of *A. digitatum* to potting impact
629 (Pot Type x Site(Location), $P < 0.05$, Table S8; Supplementary material), and while no
630 significant pairings were identified there were significantly more individuals not damaged
631 than damaged. The distribution of all indicator taxa was patchy, but it is important to note
632 that pots were not damaging all individuals that fell within the total possible contact area,
633 and instances of removal were uncommon.

634

635



636

637 **Figure 8: Number of individuals (individuals m⁻² ± SE) of the 5 indicator species, *Alcyonium***
 638 ***digitatum*, Branching sponges, *Cliona celata*, *Eunicella verrucosa*, and *Pentapora foliacea***
 639 **at the different Locations (SP = Start Point, ML = Mewstone Ledges, HP = Hillsea Point) and**
 640 **different Year (1 = 2014, 2 = 2015). Note the scales on the Y axis vary.**

641

642 3.3.3 Response by body type

643 Both groups of species (erect emergent, low encrusting) were impacted by pot hauling, and
 644 this was consistent across pot types ($p > 0.05$) for both groups. Small effect sizes for
 645 comparisons between pot types within each response type were observed, with Wilcoxon r

646 values up to 0.142 for erect emergent species, and 0.099 for low encrusting species
 647 (Supplementary Material, Table S10).

648

649 For erect emergent species, the proportion of species not damaged was greater than that of
 650 those damaged or removed, but for low encrusting species the fraction of species in the
 651 damaged and no damage categories were similar (Table 6). The response of low encrusting
 652 species is more variable, but this may be due to the lower number of samples in which low
 653 encrusting species were recorded (Table 6).

654 **Table 6: Responses of benthic fauna to pot hauling by body type and pot type. Fractional**
 655 **abundance responses of each body type were calculated for each pot prior to calculation of**
 656 **mean values, 95 % confidence intervals (CI) and Standard Error (SE).**

Pot type	Response	Erect emergent					Low encrusting				
		n	Mean fraction	Lower CI	Upper CI	SE	n	Mean fraction	Lower CI	Upper CI	SE
Inkwell	No damage	43	0.664	0.589	0.736	0.036	19	0.504	0.311	0.714	0.109
	Damaged	43	0.311	0.238	0.385	0.039	19	0.486	0.275	0.684	0.109
	Removed	43	0.025	0.013	0.042	0.007	19	0.011	0.000	0.032	0.011
Parlour	No damage	46	0.706	0.628	0.775	0.038	12	0.597	0.333	0.833	0.135
	Damaged	46	0.261	0.192	0.342	0.038	12	0.389	0.153	0.667	0.137
	Removed	46	0.033	0.015	0.056	0.01	12	0.014	0.000	0.042	0.014

657

658

659 4. DISCUSSION

660

661 This study aimed to determine whether, with the removal of trawling, potting allows for
 662 greater relative health of the ecosystem, and to quantify the mechanisms and true footprint
 663 of potting. The results have shown that whilst areas fished with static gear (predominantly
 664 pots) had consistently greater abundance, species richness and diversity than those open to
 665 bottom towed fishing, significant differences were only identifiable for assemblage
 666 composition and abundance of cover taxa, where there was significantly greater abundance

667 in static treatments (partial acceptance of hypothesis 1). They have also shown that the
668 seabed contact area is smaller than the total possible contact area for both pot types, with
669 contact areas smaller for parlour pots, and seabed contact area increasing linearly with strip
670 length (distance travelled during the haul), (acceptance of hypothesis 2). Finally, despite
671 significant spatial and temporal variation, significantly more species were not damaged within
672 the total possible contact area than were damaged or removed, but, 25-30% of taxa were
673 damaged or removed, and erect emergents were found to be particularly vulnerable to pot
674 impact (acceptance of hypothesis 3).

675

676 **4.1 Benthic condition**

677 For a system to be considered fully functional it would be expected that in addition to
678 significant differences in assemblage composition, abundance, diversity and species richness
679 would be significantly greater in static gear areas (Tett et al., 2013) and this was not the case.
680 The finding of a significant difference in assemblage composition was, however, important.
681 Species characterising areas fished with static gear were more representative of fully
682 functional benthic rocky reef areas than areas open to bottom towed fishing gear. This was
683 demonstrated by a greater abundance of all but one taxa and differences between treatments
684 being driven by biogenic habitat forming species of hydroid, bryozoan and soft coral (Beck et
685 al., 2001; Beukers-Stewart and Beukers-Stewart, 2009; Dayton et al., 1995; Jennings and
686 Kaiser, 1998; Jennings et al., 2001; Monteiro et al., 2002; Ryer et al., 2004). Biogenic habitat
687 is particularly important for slowing water movement and stabilising sediment, increasing
688 structural complexity and promoting greater biodiversity and productivity through increasing
689 the range of habitats and surface area for settlement (Bradshaw et al., 2003).

690

691 The results are in partial agreement with those of others studies considering potting impacts,
692 most of which identified no significant negative impacts. It has confirmed, however, that
693 there are potential concerns with potting identified here, which most other studies have not
694 identified, and consequently that potting is more destructive than originally thought. Eno et
695 al. (2001) concluded that pot fishing had no immediate detrimental effect on the benthos,
696 finding no significant difference in abundance of taxa before and after potting impacts.
697 Coleman et al. (2013) found no detectable effect of potting on benthic assemblages over a
698 four year period at Lundy Island (UK) with differences over time apparent in both potted and
699 control sites. Stephenson et al. (2017) found no decline in abundance of benthic species even
700 following periods of intensive potting in NE England (equivalent to 30,000 pot hauls month⁻¹
701 km⁻²), as they also identified any changes in their control areas. They concluded that even
702 where potting activity causes damage to erect species, the frequency with which a pot would
703 be expected to impact the same area twice means that species would be able to recover
704 (recovery time given as 6-36 months) sufficiently between fishing events (Stephenson et al.,
705 2017).

706

707 In contrast, and similarly to this study, the findings of Rees (2018) raised some concerns. They
708 concluded that that only cessation of potting activity would truly permit recovery of species
709 following the removal of bottom towed fishing gear within an MPA (Rees, 2018). The study,
710 which experimentally potted at different intensities, found significant treatment impacts for
711 the indicator species *P. foliacea* and *Phallusia mammillata* with abundance especially
712 impacted in high intensity potting areas (Rees, 2018).

713

714 In addition, the results of this study can be compared to those of Blyth et al. (2004) who
715 surveyed the IPA area in 2002 and concluded that areas fished using static gear had
716 significantly greater species richness and biomass than sites open to bottom towed fishing
717 gear, and also partially of Sheehan et al. (2015) who identified recovery of benthic
718 assemblages in the Lyme Bay MPA despite the continuation of potting activity. The
719 differences between these findings and the results of the current study may suggest a decline
720 in species richness over time in the survey area, may be a result of differences in survey
721 methodology and metrics (Sheehan et al., 2016) or may be down to external factors such as
722 natural variation or fishing pressure at a local or regional scale (Babcock et al., 1999).

723

724 When considering the potential for external factors to confound the results of this study, the
725 winter storms of 2013/2014 must be acknowledged. These were substantial in the south-west
726 of the UK and would have had an impact on benthic communities. Wave height in the study
727 area reached 5.25 m during the peak of the storms in February 2014 compared to an average
728 annual wave height for the period 2007 – 2013 of 3.69 m (Channel Coastal Observatory, 2014).
729 The storm season prevented fishers from going to sea to retrieve their gear, so pots were left
730 on the ground (in water depth of approximately 60 m) with many losses suffered (South
731 Devon & Channel Shellfishermen Ltd, Pers comm.). A study carried out in Lyme Bay on
732 comparable habitat into the impacts of the 2013/2014 storms found significant reductions in
733 abundance, diversity and richness after the storms, and significant impacts on selected
734 indicator taxa within the MPA. Sites closed to bottom towed fishing gear became more similar
735 to those open to bottom towed fishing gear outside the MPA (Sheehan et al, unpublished
736 data), and due to the proximity of Lyme Bay to the IPA, it may be that similar trends would
737 have been identified here if temporal comparisons were possible with sufficient 'before' data.

738 In a study of Caribbean lobster traps, Lewis et al. (2009) found that movement during storms
739 and hurricanes caused abrasion, fragmentation and removal of corals and sponges with a
740 reduction in benthic species cover. The true impacts of potting may therefore have been
741 confounded by impacts from the storms and this must be acknowledged in interpretation of
742 the results.

743

744 **4.2 Mechanisms of potting interaction**

745 This study is the first of its kind to quantify the seabed contact area during pot hauls. It has
746 shown that the haul is the period during which damage may be caused by potting activity, but
747 the finding that seabed contact area is roughly half that of the total possible contact area is
748 of importance for furthering understanding of potting impact. Furthermore, the existence of
749 significant differences in impact between parlour and inkwell pots may be of relevance to
750 future decisions on sustainable potting gear and management of potting activity, particularly
751 where habitats may be considered to be at risk.

752

753 **4.3 True footprint of potting**

754 Significant spatial and temporal variation was apparent in the data, but despite this,
755 significantly more species were not damaged than were damaged or removed. With the
756 exception of *D. violacea* which was not directly contacted by the pots, the species not
757 damaged were sedentary but mobile. Similarly to the observations made by Eno et al. (2001)
758 about sea pens in soft sediment, it was noted that mobile taxa were moved out of the way of
759 the pot by the pressure wave caused as it neared the seabed, suggesting that they are less
760 susceptible to damage than sessile species.

761

762 Damage included abrasion, and removal of sections of the individual. 25-30 % of taxa were
763 damaged or removed and all five indicator species were damaged in some way, with more
764 instances of damage than no damage occurring for *C. celata*, *E. verrucosa* and *P. foliacea*.
765 These taxa are long-lived and slow growing species that were thought to be most susceptible
766 to potting impacts and would take the longest to recover (Langmead et al., 2010). Impacts of
767 abrasion are not well studied, but evidence suggests that species such as sponges and soft
768 corals may be left vulnerable to disease (Bavestrello et al., 1997; Hiscock, 2007; Shester and
769 Micheli, 2011; Wassenberg et al., 2002). Abrasion was observed for *E. verrucosa*, and
770 although colonies are thought to be able to re-grow over a period of about 1 week if damaged
771 (Hiscock, 2007), if areas of the coenenchyme are scraped off and recovery fails to occur
772 promptly they may be vulnerable to colonisation by epibiota (Bavestrello et al., 1997). This
773 could cause mechanical stress through increased resistance to water movement, and
774 susceptibility to weakening from the burrowing activities of epibiota.

775

776 Two indicator species known to be important for ecosystem function were *E. verrucosa* which
777 creates complex elevated surfaces available for the settlement of spat and acts as habitat for
778 other organisms (Howarth et al., 2011; Jones et al., 1994) and *P. foliacea* a functionally
779 important bio-constructor forming biogenic reefs (Cocito and Ferdeghini, 2001; McKinney and
780 Jackson, 1989) and structurally complex habitat important as a nursery habitat for juvenile
781 fish (Bradshaw et al., 2003). Impacts on these two species would be of particular concern due
782 to their long projected recovery time of 17-20 years (Kaiser et al., 2018). In the case of *E.*
783 *verrucosa*, although few instances occurred where a pot landed directly on top of an
784 individual, where this did occur the results were similar to those of other studies. Eno et al.
785 (2001) observed that it tended to 'bounce back' once the pot had passed, while Shester and

786 Micheli (2011) reported no incidence of removal of gorgonians as a result of lobster trap
787 impact in the Gulf of Mexico and Rees (2018) found that whilst abundance decreased over
788 time in areas fished at the highest potting density (~30 pots per 500m²), this was not
789 significant.

790

791 Pots contacting *P. foliacea* commonly caused pieces to break off. Of the 16 colonies observed,
792 only one was removed from the reef, but their fragile and brittle structure meant that more
793 individuals were damaged than not damaged. The longer-term implications of damage are
794 unknown, and due to the low abundance of *P. foliacea* across the study site, conclusions were
795 not possible. The findings of Rees (2018) of a significant difference in abundance between
796 control/low potting density sites and medium/high density sites may be cause for concern,
797 however. This study did not calculate potting density across the site so direct comparisons
798 cannot be made, but the results of Rees (2018) suggest that impacts may be more substantial
799 in areas where abundance is greater. What can be concluded here is that as abundance was
800 greater in the static treatment, the impact of potting has a lesser effect than the impact of
801 trawling on this species; a conclusion also drawn by Sheehan et al. (2015).

802

803 When considering body type, the finding that despite their greater vulnerability, a smaller
804 proportion of erect emergents were damaged or removed compared to those not damaged
805 is of note. For low encrusting organisms, similar numbers were damaged and not damaged.
806 The greater variability seen for these taxa may be due to the low number of encrusting species
807 recorded, or it may be a result of pots making contact with a larger area of the species in
808 question owing to differences in morphology between body types. The work of Stephenson
809 et al. (2017) which found no significant impact of potting on benthic organisms also

810 commented that encrusting species are unlikely to be damaged as their size and shape enable
811 them to withstand impacts from physical disturbance and abrasion; a result which does not
812 seem to hold true here.

813

814 **4.4 Implications for management**

815 This study has contributed to the evidence base for assessing the impact of potting on
816 temperate rocky reefs. It is the first study to quantify the true footprint of potting, the first to
817 use GoPro cameras for such work, and one of the first to consider the impact of a string of
818 pots throughout their deployment, soak and haul. The findings suggest that current levels of
819 potting within the IPA are allowing benthic condition to be maintained and the relative health
820 of the ecosystem to be greater than in adjacent areas where bottom towed fishing gear
821 operates, but they have raised concerns over impacts, in particular those to some long lived
822 and slow growing taxa, which are particularly sensitive to potting. The haul has been identified
823 as the time during which most impacts may occur, and despite the fact that the area of
824 damage is not the entire pot haul path, potting has been found to be more destructive than
825 previously thought.

826

827 In particular, the damage caused to sensitive taxa may be of concern; and with the longer-
828 term impacts unknown it is difficult to predict the consequences. The behaviour of pot fishing
829 makes it very unlikely that pots would be deployed such that they would land, soak and haul
830 in the same location on successive trips, however (Eno et al., 2001), and a recovery time of
831 between 6-36 months for the majority of species (Jackson, 2004; Tyler-Walters, 2006; Tyler-
832 Walters & Ballerstedt, 2007; Budd, 2008) also gives some confidence that species may recover
833 without further disturbance occurring (Stephenson et al., 2017). Consideration must however,

834 be given to recovery trajectories of the most sensitive species which may be as long as 17-20
835 years (Kaiser et al., 2018). The presence of these species throughout the potted areas of the
836 IPA, and the time over which the IPA management has been in place suggests that the reefs
837 may be resilient to current potting levels, but the lack of comparable historical data prevents
838 temporal comparisons and it is unknown whether abundance would be greater if potting
839 levels were reduced or potting was no longer permitted in the area.

840

841 The call for ecosystem based fisheries management means that regulators must decide what
842 level of impact is 'acceptable' and will not compromise the ability of an MPA to meet defined
843 conservation objectives and targets. The D&SIFCA have responsibility for this in the study area.
844 Alongside consideration of ecological impact, they must consider the value of the fishing
845 activity occurring within a protected area and determine the social and economic impacts of
846 management decisions. This study has contributed to a decision to allow potting activity to
847 continue at current levels in the Start Point to Plymouth Sound & Eddystone SCI highlighting
848 its value in supporting decision-making (D&SIFCA, pers. comm.). Continued monitoring of the
849 IPA is required, however, to ensure continued confidence in this decision, and the adaptive
850 management approach of the D&SIFCA should mean that if any decline was identified the
851 continuation of potting in the area would be reviewed.

852

853 The results will be applicable globally where similar habitats and species are found and similar
854 potting methods used. As such, they are particularly important in light of the global drive to
855 increase the coverage of MPAs in order to meet Aichi Biodiversity Target 11 by 2020, and the
856 need to take an ecosystem approach to management, which incorporates social and
857 economic elements (CBD, 2010; Pikitch et al., 2004; Gaines et al., 2010). The increasing

858 designation of multi-use MPAs necessitates identification of extractive activities, which are
859 compatible with meeting conservation goals whilst supporting a viable fishing industry.
860 Potting may be such an activity, but the results suggest careful monitoring of impact is needed,
861 as it cannot be described as a benign fishing method. Furthermore, the issue of shifting
862 baselines must be recognised, especially with regard to what constitutes a fully functional
863 rocky reef ecosystem as continued anthropogenic pressure may result in gradual change and
864 loss of ecosystem services if management measures are not effective (Tett et al., 2013).

865

866 **4.5 Further work**

867 The body of literature surrounding the impact of potting has grown, but the differences
868 between the findings of this and other studies suggest that, as expected, more research is
869 required to further knowledge and understanding of potting impacts. Any future work should
870 build on that already completed. In particular, this work has highlighted the need for
871 consideration of impacts on key species, the effect of depth, string length and position of pot
872 on the string, and development of long-term studies, which can assess change over time and
873 have the power to overcome confounding factors.

874

875

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886

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1180 **Supplementary material**

1181 **Description of pot setting and hauling process**

1182 When setting pots, the fishers used cast iron end weights at either end of the sting. The skipper set
 1183 the boat on course and steamed slowly whilst the gear deployed. The end weight was deployed first
 1184 and then each pot followed in turn and was taken through an open door in the side of the vessel
 1185 once the slack rope had become taught. Pots and ropes were arranged on deck such that they
 1186 deployed automatically as the boat steamed. Once the final end weight was deployed, the surface
 1187 bouy followed, and the pots were left on the sea bed.

1188 The haul process involved picking up the surface bouy, then winching the line in so that the end
 1189 weight and then each pot re-entered the vessel over the side to be stacked on deck in turn and the
 1190 rope coiled ready for the next deployment.

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1192 **Results for benthic condition**

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1194 **Table S1: PERMANOVA to test the differences in number of count and cover individuals between**
 1195 **Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and**
 1196 **Treatments (Static, Mixed). Data were fourth root transformed prior to the construction of a**
 1197 **Euclidean distance resemblance matrix. Bold values indicate significant differences**

1198

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>Pseudo-F</u>	<u>P(perm)</u>	<u>Source</u>	<u>df</u>	<u>MS</u>	<u>Pseudo-F</u>	<u>P(perm)</u>
<i>Count taxa</i>					<i>Cover taxa</i>				
Ye	2	3820.50	3.08	0.001	Ye	2	3338.60	1.97	0.07
Tr	1	12338.00	1.57	0.08	Tr	1	19842.00	3.41	0.01
Lo(Tr)	8	6756.80	2.89	0.000	Lo(Tr)	8	4890.30	1.79	0.002
YexTr	2	1925.50	1.58	0.07	YexTr	2	1429.70	0.86	0.51
Si(Lo(Tr))	20	1345.30	1.67	0.0001	Si(Lo(Tr))	20	1591.50	1.52	0.02
YexLo(Tr)	16	1212.80	1.51	0.0004	YexLo(Tr)	16	1656.80	1.59	0.02
Res	37	804.24			Res	37	1045.20		
Total	86				Total	86			

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1202 **Table S2: PERMANOVA to test the differences in number of taxa and diversity (Simpsons 1-λ)**
 1203 **between Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in**
 1204 **Location) and Treatments (Static, Mixed). Data were fourth root transformed prior to the**
 1205 **construction of a Euclidean distance similarity matrix. Bold values indicate significant differences**

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<u>Source</u>	<u>df</u>	<u>MS</u>	<u>Pseudo-F</u>	<u>P(perm)</u>	<u>Source</u>	<u>df</u>	<u>MS</u>	<u>Pseudo-F</u>	<u>P(perm)</u>
<i>Number of taxa</i>					<i>Diversity</i>				
Ye	2	0.10	7.55	0.01	Ye	2	0.00	0.17	0.85
Tr	1	0.26	3.44	0.07	Tr	1	0.01	0.27	0.95
Lo(Tr)	8	0.07	1.25	0.26	Lo(Tr)	8	0.04	1.72	0.06
YexTr	2	0.01	0.91	0.43	YexTr	2	0.01	2.00	0.16
Si(Lo(Tr))	20	0.05	4.97	0.0001	Si(Lo(Tr))	20	0.02	3.38	0.0004
YexLo(Tr)	16	0.01	1.37	0.21	YexLo(Tr)	16	0.01	1.28	0.27
Res	37	0.01			Res	37	0.01		
Total	86				Total	86			

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Table S3: ANOVA to test the differences in number of individuals of the indicator taxa *Alcyonidium diaphanum*, *Alcyonium digitatum*, Branching sponges, *Cliona celata*, *Eunicella verrucosa*, *Metridium senile*, *Pentapora foliacea* and *Urticina felina* between Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and Treatments (Static, Mixed). Pairwise tests were used to examine significant interactions between fixed factors. Data were fourth root transformed prior to the construction of a Euclidean distance resemblance matrix. Bold values indicate significant differences.

Source	df	MS	Pseudo-F	P(perm)	Source	df	MS	Pseudo-F	P(perm)	M&S	
<i>Alcyonidium diaphanum</i>					<i>Alcyonium digitatum</i>						
Ye	2	3.91	8.53	0.003	Ye	2	0.35	2.57	0.11	2013	0.073
Tr	1	0.75	0.70	0.64	Tr	1	19.09	6.56	0.01	2014	0.017
Lo(Tr)	8	1.56	2.31	0.01	Lo(Tr)	8	2.41	5.01	0.0001	2015	0.024
YexTr	2	0.18	0.40	0.66	YexTr	2	0.54	4.01	0.04		
Si(Lo(Tr))	20	0.31	1.33	0.22	Si(Lo(Tr))	20	0.39	1.43	0.17		
YexLo(Tr)	16	0.45	1.88	0.06	YexLo(Tr)	16	0.13	0.49	0.94		
Res	37	0.24			Res	37	0.27				
Total	86				Total	86					
<i>Branching sponges</i>					<i>Cliona celata</i>						
Ye	2	0.04	1.95	0.18	Ye	2	0.01	1.69	0.21		
Tr	1	0.43	2.39	0.14	Tr	1	0.11	5.02	0.02		
Lo(Tr)	8	0.18	3.55	0.001	Lo(Tr)	8	0.02	1.48	0.13		
YexTr	2	0.01	0.69	0.52	YexTr	2	0.01	0.85	0.45		
Si(Lo(Tr))	20	0.03	1.48	0.13	Si(Lo(Tr))	20	0.01	1.09	0.39		
YexLo(Tr)	16	0.02	0.92	0.56	YexLo(Tr)	16	0.01	1.09	0.39		
Res	37	0.02			Res	37	0.01				
Total	86				Total	86					
<i>Eunicella verrucosa</i>					<i>Metridium senile</i>						
Ye	2	0.07	0.70	0.53	Ye	2	0.01	0.44	0.67		
Tr	1	0.06	0.11	1.00	Tr	1	0.22	3.76	0.05		
Lo(Tr)	8	1.30	8.54	0.0001	Lo(Tr)	8	0.05	1.54	0.11		
YexTr	2	0.11	1.12	0.36	YexTr	2	0.01	0.75	0.51		
Si(Lo(Tr))	20	0.05	2.79	0.004	Si(Lo(Tr))	20	0.03	1.13	0.34		
YexLo(Tr)	16	0.10	5.17	0.0001	YexLo(Tr)	16	0.02	0.77	0.76		
Res	37	0.02			Res	37	0.03				
Total	86				Total	86					
<i>Pentapora foliacea</i>					<i>Urticina felina</i>						
Ye	2	0.03	5.17	0.02	Ye	2	0.18	3.55	0.04		
Tr	1	0.01	1.25	0.36	Tr	1	0.10	0.38	0.88		
Lo(Tr)	8	0.01	1.43	0.15	Lo(Tr)	8	0.39	4.75	0.0001		
YexTr	2	0.00	0.23	0.79	YexTr	2	0.03	0.52	0.62		
Si(Lo(Tr))	20	0.00	1.34	0.20	Si(Lo(Tr))	20	0.04	1.16	0.33		
YexLo(Tr)	16	0.01	2.08	0.03	YexLo(Tr)	16	0.05	1.65	0.10		
Res	37	0.00			Res	37	0.03				
Total	86				Total	86					

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Table S4: Results of SIMPER showing the contribution of different species to the differences seen between Mixed and Static treatments. * denotes indicator species. Bold text denotes the higher abundance.

	Mean abundance		Diss/SD	Contrib%
	Mixed	Static		
Turf	0.26	0.48	1.47	9.44
* <i>Alcyonium digitatum</i>	0.13	0.47	1.41	9.43
Unidentified hydroid species	0.72	0.81	1.01	8.45
* <i>Alcyonidium diaphanum</i>	0.23	0.29	1.22	6.78
<i>Nemertesia antennina</i>	0.17	0.30	1.28	6.10
<i>Ophiothrix fragilis</i>	0.06	0.14	0.49	4.83
<i>Ophiocomina nigra</i>	0.06	0.16	0.77	4.55
Unidentified bryozoan species	0.12	0.11	0.91	3.75
* <i>Eunicella verrucosa</i>	0.07	0.10	0.62	3.20
* <i>Urticina felina</i>	0.05	0.09	0.69	2.79
<i>Pecten maximus</i>	0.10	0.05	0.66	2.68
<i>Halecium halecinum</i>	0.06	0.10	0.99	2.62
<i>Lanice conchilega</i>	0.04	0.05	0.43	2.41
<i>Cellepora pumicosa</i>	0.08	0.06	0.75	2.34
<i>Nemertesia ramosa</i>	0.04	0.08	0.95	1.97
<i>Flustridae</i> spp.	0.01	0.06	0.49	1.58
<i>Unidentified anemone</i>	0.05	0.02	0.47	1.52
Unidentified macroalgae	0.04	0.02	0.56	1.47
<i>Aequipecten opercularis</i>	0.04	0.01	0.67	1.38
Unidentified cup coral	0.02	0.05	0.59	1.35
<i>Dendrodoa grossularia</i>	0.00	0.05	0.43	1.20
<i>Echinus esculentus</i>	0.01	0.05	1.02	1.20
Branching sponge 1	0.01	0.04	0.72	1.16
<i>Marthasterias glacialis</i>	0.02	0.04	0.84	1.08
<i>Cliona celata</i>	0.00	0.04	0.72	1.01
<i>Metridium senile</i>	0.04	0.00	0.41	0.99
<i>Cerianthid</i> spp.	0.04	0.00	0.38	0.92
Branching sponge 2	0.00	0.04	0.50	0.87
<i>Sycon ciliatum</i>	0.02	0.03	0.87	0.83
<i>Pagurus bernhardus</i>	0.03	0.00	0.58	0.78
<i>Pentapora foliacea</i>	0.02	0.03	0.80	0.75
<i>Aglaophenia tubulifera</i>	0.03	0.01	0.45	0.74

Average dissimilarity M : S = 60.64

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1236 **Mechanisms of potting interaction**

1237 **Table S5: PERMANOVA to test the differences in mechanisms of potting interaction between Years**
 1238 **(Yr, 2014, 2015), Locations (Lo, Start Point, Mewstone Ledges, Hillsea Point), Sites (Si, 1-9, nested in**
 1239 **Location) and Pot Types (Po, Inkwell, Parlour). Pairwise tests are used to examine significant**
 1240 **interactions between fixed factors. Data were untransformed prior to the construction of a Euclidean**
 1241 **Distance resemblance matrix. Bold values indicate significant differences.**

a)					b)			
Source	df	MS	Pseudo-F	P(perm)	Pairing	SP	ML	HP
Ye	1	3994.7	2.1721	0.276	Site 1			
Lo	2	867.56	0.69558	0.7059	P & I	0.4763	0.2478	0.2484
Po	1	962.86	1.391	0.3825	Site 2			
Si(Lo)	24	641.58	0.77098	0.7364	P & I	0.2489	0.2413	0.2412
YexLo	2	1778.1	2.1448	0.1355	Site 3			
YexPo	1	616.41	3.43	0.2075	P & I	-	0.4896	-
LoxPo	2	143.23	0.57233	0.8087	Site 4			
YexSi(Lo)**	23	816.47	2.632	0.0174	P & I	0.2384	-	0.4948
PoxSi(Lo)	24	697.27	2.2584	0.0381	Site 5			
YexLoxPo	2	140.14	0.45176	0.6454	P & I	0.2342	0.504	0.2387
Res	19	310.21			Site 6			
Total	101				P & I	0.2467	0.2478	0.2363
** Term has one or more empty cells					Site 7			
					P & I	0.522	0.5015	0.2641
					Site 8			
					P & I	-	0.2662	0.2239
					Site 9			
					P & I	-	0.5249	0.2344

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1243 **Table S6: Contact area (m2) by pot type and linear relationship of contact area against strip**
 1244 **length. Confidence level = 0.95. NB. Differences in mean occur between these figures and the**
 1245 **statistical analysis as no pooling was required for this analysis.**

Pot type	Mean effect	Lower CI	Upper CI	SE	Intercept ± CI	Slope ± CI	Adjusted R ²
Inkwell	2.12	1.91	2.34	0.108	0.699 ± 0.328	0.317 ± 0.054	0.614
Parlour	1.60	1.38	1.81	0.108			

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1247 **Table S7: Pot-specific regression coefficients for the effect of strip length on pot contact area.**

Pot type	Mean effect	Lower CI	Upper CI	SE	Intercept ± CI	Slope ± CI	Adjusted R ²
Inkwell	2.12	1.91	2.34	0.109	0.688 ± 0.415	0.319 ± 0.077	0.610
Parlour	1.60	1.38	1.81	0.109	0.185 ± 0.400	0.314 ± 0.077	

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1249 Pot-specific responses derived from the model Contact area ~ Strip length * Pot type. This model did
 1250 not perform as well (based on AIC) as the model Contact area ~ Strip length + Pot type, suggesting

1251 that there is no interaction between pot type and strip length. Pot types both respond similarly to
 1252 movement along the seabed in terms of their contact areas.

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True footprint of potting

1257 **Table S8: PERMANOVA to test the differences in true footprint between Years (Yr, 2014, 2015),**
 1258 **Locations (Lo, Start Point, Mewstone Ledges, Hillsea Point), Sites (Si, 1-9, nested in Location) and**
 1259 **Pot Types (Po, Inkwel, Parlour). Pairwise tests are used to examine significant interations between**
 1260 **fixed factors. Data were untransformed prior to the construction of a Euclidean Distance**
 1261 **resemblance matrix. Bold values indicate significant differences.**

a)					b)			
Source	df	MS	Pseudo-F	P(perm)		SP	ML	HP
Ye	1	16052	2.4495	0.1171	2014			
Lo	2	19696	1.9914	0.0248	ND & D	0.6804	0.0015	0.0026
Po	1	4754.3	1.4815	0.2381	ND & R	0.0154	0.0003	0.0003
Re	2	84028	7.3349	0.0002	D & R	0.0071	0.0008	0.0049
Si(Lo)	25	4963.7	1.4588	0.0363	2015			
YexLo	2	6235	1.8007	0.0873	ND & D	0.1719	0.0011	0.0021
YexPo	1	3826.9	1.0687	0.4323	ND & R	0.0016	0.0002	0.0003
YexRe	2	5651.7	1.6358	0.1593	D & R	0.0021	0.0047	0.0597
LoxPo	2	1546.7	0.64817	0.9011				
LoxRe	4	6123.2	1.5427	0.0259				
PoxRe	2	606.5	1.0605	0.449				
YexSi(Lo)**	23	3397.6	No test					
PoxSi(Lo)**	24	3930.3	1.2702	0.1211				
Si(Lo)xRe**	48	1574.4	0.96096	0.625				
YexLoxPo	2	3402.9	1.1025	0.359				
YexLoxRe	4	3324.9	2.0645	0.0088				
YexPoxRe	2	964.37	0.59191	0.8437				
LoxPoxRe	4	1315.8	0.88001	0.6917				
YexPoxSi(Lo)**	19	3079.6	No test					
YexSi(Lo)xRe**	46	1576.3	No test					
PoxSi(Lo)xRe**	48	1286.2	0.93635	0.6863				
YexLoxPoxRe	4	1721.9	1.2566	0.2115				
Co(YexPoxSi(Lo))	0		No test					
YexPoxSi(Lo)xRe**	37	1370.2	No test					
Total	305							

** Term has one or more empty cells

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1273 **Table S10: Effect size (Wilcoxon r) and 95 % confidence intervals of pot type (inkwell and parlour)**
 1274 **on fractions of individuals damaged, removed, or exhibiting no damage as a response to pot hauling.**
 1275 **Effect sizes calculated using the package coin (Hothorn et al., 2008) in the R programme (R core team**
 1276 **2019).**

Response	Erect emergent			Low encrusting		
	Effect size	Lower CI	Upper CI	Effect size	Lower CI	Upper CI
No damage	0.139	0.0096	0.34	0.099	0.0078	0.44
Damaged	0.142	0.0079	0.35	0.091	0.0041	0.44
Removed	0.010	0.0022	0.23	0.051	0.0074	0.40

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