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5 **Cluster analysis reveals latent structure in stakeholder interests relevant to the**
6 **management of Blueskin Bay estuary, Otago, Aotearoa New Zealand**

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14 **Cluster analysis reveals latent structure in stakeholder interests relevant to the**
15 **management of Blueskin Bay estuary, Otago, Aotearoa New Zealand**

16

17 **ABSTRACT**

18 Community participation is increasingly embedded into environmental policy with the aim of
19 accelerating transformative change towards sustainable management. A common approach to
20 engage with communities is through key stakeholders who are still often selected *ad hoc* based on
21 their activities. We tested an analytical approach for identifying distinct groups of community
22 preferences as part of a case study to develop a community-led management plan for Blueskin Bay
23 estuary and its catchment. We interviewed 36 community members to elicit their preferences for
24 predefined management objectives following a standardized protocol. Using an agglomerative
25 hierarchical analysis, we determined value-preference clusters for high-level management
26 objectives and for more specific sub-objectives. At both levels combined, preference clusters were
27 attributed to some of the commercial interests, such as cockle harvesting, forestry, or tourism,
28 which we also identified *ad hoc* based on their activities in the Blueskin Bay area. However, in
29 addition cluster analyses revealed five additional preference types, which we termed Urbanization
30 Development Advocates, Cultural Environmentalists, Economic Environmentalists, Integrative
31 Thinkers and those with Diverse Interests. We conclude that cluster analysis more objectively and
32 specifically maps community preferences and, consequently, increases the robustness of
33 collaborative environmental management processes such as the one underway for Blueskin Bay
34 estuary.

35

36 **Key words:** Blueskin Bay; ecological quality; estuary; hierarchical cluster analysis; integrative
37 management; multi-attribute value theory; multi-criteria analysis; National Policy Statement for
38 Freshwater Management; public participation; stakeholder engagement

39

40

41 **Introduction**

42 Estuaries are unique ecosystems between land and sea that represent hotspots of biodiversity,
43 biogeochemical processes, and biological production (Douglas, Lohrer, & Pilditch, 2019; Kennish,
44 2002). They are also sites of diverse social, cultural, and economic significance which makes them
45 among the most valuable, yet also among the most threatened and degraded ecosystems on earth
46 (Barbier et al., 2011; Costanza et al., 2014). A reason for that is that estuaries accumulate both
47 proximal, direct effects of human activities localised in and around the estuary in addition to more
48 distal, indirect effects resulting from catchment-based activities (Keneley, O'Toole, Coffey, &
49 MacGarvey, 2013). In Aotearoa New Zealand (hereafter 'NZ'), for example, estuaries face local
50 and catchment-wide issues including excessive nutrient loads and associated estuarine algal blooms,
51 excessive sediment loads leading to enhanced sedimentation, chemical and waste pollution,
52 pathogens, fish and shellfish harvesting, and the disturbance of estuary beds and margins (New
53 Zealand Parliamentary Commissioner for the Environment, 2020). Accordingly, effective,
54 catchment-scale estuary management is a pressing issue, not only in NZ but worldwide (Lotze et
55 al., 2006). However, decisions about how to manage (i.e. restore, conserve and use estuaries) are
56 highly complex and including local communities in the decision making process is invaluable
57 (Keneley et al., 2013).

58 Community participation in environmental decision-making has been increasingly
59 embedded into national and international policy, as embracing the diversity of knowledge and
60 values is thought to result in flexible and transparent decision-making for complex issues (Innes &
61 Booher, 2018; Nissen, 2014; Reed, 2008; Sinner, Newton, & Duncan, 2015). When performed
62 effectively (Biddle, 2017; Durham, Baker, Smith, Moore, & Morgan, 2014), community
63 participation integrates local and scientific knowledge and, therewith, provides a more
64 comprehensive understanding of the relevant complex and dynamic social, ecological, cultural, and
65 economic processes indicative of a particular system (Gray, Chan, Clark, & Jordan, 2012). In turn,
66 when the decision-making process considers people's interests, values, and concerns, the likelihood
67 that the project will successfully meet local needs and priorities is increased (Dougill et al., 2006).
68 In addition, giving people a voice leads to decision-making processes that educate the public, are
69 more resilient to local vested interests, and can change attitudes of participants towards more robust
70 and longer term outcomes (Biddle & Koontz, 2014; M. S. Reed, 2008; Sterling et al., 2017). In
71 effect, collaborative decision-making processes facilitate the implementation and sustainability of
72 management actions (Webler & Tuler, 2021).

73 Over the past two decades, community participation has also become an integral part of
74 water governance and resource management (Carr, Bloschl, & Loucks, 2012), progressing from
75 earlier directives which encouraged stakeholder collaboration, e.g. the European Union Water

76 Framework Directive (European Commission, 2000, 2003) or the Clean Water Act (United States,
77 1972) to more recent regulations mandating community engagement (e.g. (Australian Government,
78 2018; New Zealand Ministry for the Environment, 2020). For example, Sections 3.3, 3.4 and 3.7 of
79 the New Zealand National Policy Statement for Freshwater Management (which also encompasses
80 estuaries) mandate engagement and active involvement with stakeholders and *tangata whenua*
81 (Māori) in the development of long term visions for freshwater management, for locally relevant
82 implementation of policy, for the setting of environmental limits, and for agreeing on appropriate
83 monitoring strategies (New Zealand Ministry for the Environment, 2020). A common way of
84 facilitating community participation in catchment management is through engagement with key
85 stakeholders (i.e. people who hold a “stake”, i.e. an interest in the matter of the decision-making
86 process), whose opinions inform the decision-making process and shape outcomes. Key
87 stakeholders in catchment management processes are typically selected based on whether they
88 either hold an economic interest located within the river catchment (e.g. forestry, infrastructure
89 development, or hydropower production etc.), use the waterways for social activities (e.g. fishing,
90 swimming, customary use etc.), or represent (governmental or non-governmental) environmental
91 organisations and agencies (Barbosa et al., 2019; De Stefano, 2010; Junker, Buchecker, & Mueller-
92 Boeker, 2007; Morrison, 2003; Nissen, 2014). The status of participating indigenous rights holders
93 can differ among and within countries. In NZ, *tangata whenua* (indigenous *iwi* (tribes) which have
94 *mana whenua* (customary authority) over a particular area) must be actively involved by the local
95 authority in freshwater management to the extent they wish to be involved (New Zealand Ministry
96 for the Environment, 2020) and, therefore, collaborate outside of a stakeholder definition (also see
97 Memon & Kirk, 2012).

98 Theory and practical experiences indicate that collaborative processes lead to more
99 sustainable and effective solutions when the full range of stakeholders, who are representative of
100 the value-preference landscape for a particular decision-making process, are involved (Junker et al.,
101 2007; Reed, 2008; but see Tadaki, Sinner, Stahlmann-Brown, & Greenhalgh, 2020, who found that
102 community confidence in the legitimacy, fairness and effectiveness of water management
103 institutions has not improved despite major investments in collaborative decision making in three
104 regions in the North Island of NZ). This is especially true if stakes greatly differ, which is a
105 common situation in water management where a variety of human interests can be at odds with
106 maintaining ecological health (Falkenmark, 2003). While engaging only with like-minded people
107 can be expedient, participatory processes that engage with relevant stakeholders are expected to be
108 more efficient and effective in the long-run (Irvin & Stansbury, 2004; Konisky & Beirele, 2001). In
109 catchment management processes, main reasons for this are fewer delays in the implementation of
110 management plans due to interventions by overlooked (or intentionally excluded) interests (Luyet,

111 2005), and buy-in from the whole community which fosters long-term sustainability of management
112 plans (Duram & Brown, 1999; Junker et al., 2007) among others, such as fostering and developing
113 social learning and improving project design using local knowledge (Luyet, Schlaepfer, Parlange, &
114 Buttler, 2012).

115 Although stakeholder selection is a vital first step in collaborative processes, it is still often
116 done *ad hoc* (Nissen, 2014; Mark S. Reed et al., 2009), based on the assumption that their values
117 align with their visible interests/activities and that each representative promotes the interests of a
118 stakeholder group that they are deemed to reflect. However, it is likely that the value preferences of
119 people are more complex than that of a single interest group. This was shown for a river restoration
120 project in Switzerland where, for the most controversial issues including naturalness, forestry,
121 recreation, and agricultural use of land, the public's preferences did not match those of the
122 stakeholder groups which are commonly involved in such projects (i.e. land owners, fishing and
123 hunting groups, NGOs, farmers union, tourism (Junker et al., 2007)).

124 Here we hypothesised that a values-based analytical approach would reveal a broader and
125 more complex spectrum of key stakeholder types compared to an a priori selection of stakeholder
126 group representatives. We tested the approach in the context of a real-world participatory process
127 that is underway to develop a community management plan for Blueskin Bay estuary and its
128 catchment in Otago, NZ.

129

130 **Material and Methods**

131 *Case study area: The Blueskin estuary and catchment*

132 Blueskin estuary is Otago's largest intertidal estuarine environment, rich in birds, shellfish, fish and
133 other forms of life (Fig. 1A, B). It is as a shallow intertidal-dominated estuary characterized by a
134 heterogenous mosaic composed of saltmarshes, estuarine sand and mudflats, estuarine seagrass
135 beds, tidal estuarine channels, and sheltered shallow sand (New Zealand Department of
136 Conservation, 2016). These habitats support a diverse flora and fauna which provide for cultural
137 and customary uses such as cockle/tuaki (*Austrovenus stutchburyi*) and flounder/patiki
138 (*Rhombosolea* spp.) harvesting, picnicking and generally enjoying the estuary and its ocean beach
139 (Fig. 1C, D). Blueskin estuary is a regionally and nationally outstanding cockle habitat providing
140 large quantities of shellfish to both recreational and commercial harvesters. The significance of the
141 estuary is acknowledged by being encompassed in the East Otago Taiāpure Management Area – a
142 fishery management arrangement with Ngāi Tahu which limits recreational takes and highlights
143 both the food gathering value of the region and the importance of protecting the aquatic resources
144 of the area for future generations (East Otago Taiapure, 2008). In addition, the estuary is a
145 designated coastal protection area in the Otago Regional Council's Regional Plan (Otago Regional

146 Council, 2012), due to its special characteristics and the vulnerability of its biota and habitats to
147 human pressures.

148 Recent observations by locals regarding the blooms of sea lettuce (*Ulva sp.*) in the estuary
149 and reductions in cockle distributions within the estuary raised concerns within the community that
150 the health of the estuary is deteriorating. Cumulative contaminant flows arise from residential areas
151 (including sewage, septic tanks, and stormwater), which will increase with the current and planned
152 residential developments. Forestry is also prevalent in the Blueskin Bay catchment and anecdotal
153 evidence suggests that soil erosion has deleterious effects on water quality and estuarine ecology in
154 Blueskin estuary. While farming in the catchment is low intensity, current land plans allow
155 intensification, which could put the estuary at risk from increasing fertilizer, sediment, and faecal
156 runoff.

157
158 *Relevant environmental policies for estuary management in New Zealand*

159 The New Zealand Coastal Policy Statement (CPS; New Zealand Department of Conservation,
160 2010) and the National Policy Statement of Freshwater Management (NPS-FM; New Zealand
161 Ministry for the Environment, 2020) are the two key policies to consider when developing estuary
162 management plans in NZ. While the CPS identifies estuaries as important ecosystems to manage as
163 their own entity, the NPS-FM emphasises the management of estuaries as part of an integrated
164 catchment management approach, recognising the connection between land, water and human
165 health. The recently released report by the New Zealand Parliament Commissioner for the
166 Environment (2020) similarly urges for estuaries to be included in freshwater management units (as
167 set out in the NPS-FM; New Zealand Ministry for the Environment, 2020) to facilitate integrated
168 management from the mountains to the sea.

169
170 *Development of a catchment-estuary management plan for Blueskin Bay*

171 With support from Blueskin Bay Watch – a local conservation-oriented community group founded
172 to represent the views of people on environmental and development issues in and around Blueskin
173 estuary – we initiated the process of developing a catchment and estuary management plan in 2019.
174 A series of four workshops were held in which 1) the Multi-Criteria Decision Analysis-framework
175 (see below) we agreed to follow was explained, 2) key community values related to the Blueskin
176 estuary and the catchment were identified, 3) objectives (i.e. suggested by the authors based on the
177 previously identified values) were arranged hierarchically from high-level (abstract) to more
178 specific (measurable) objectives, and 4) measurable system properties (i.e. indicators) were
179 identified (Fig. 2). Participation was open to the public and each of the workshops was attended by
180 40 to 60 people.

181

182 A framework for collaborative catchment management planning

183 Multi-Criteria Decision Analysis (MCDA) is an umbrella term for a collection of formal methods
184 that support complex decision situations with multiple objectives (Eisenführ, Weber, & Langer,
185 2010; Gregory et al., 2012; Gregory & Keeney, 2002). Currently, MCDA gains new momentum
186 due to its ability to integrate social objectives and stakeholder engagement in environmental
187 decision applications that involve coupled human-natural systems (Estevez, Walshe, & Burgman,
188 2013). Examples of MCDA-based catchment management and restoration planning are described in
189 Kuemmerlen, Reichert, Siber, & Schuwirth (2019), Langhans & Lienert (2016), Langhans, Lienert,
190 Schuwirth, & Reichert (2013), Langhans, Schuwirth, & Reichert (2014), Paillex et al. (2017) and
191 Reichert, Langhans, Lienert, & Schuwirth (2015). Recently, an MCDA-framework was used in
192 Otago, NZ, to contribute to a community-based catchment management plan for Lake Wanaka and
193 its upper catchment and provides a thorough description and review of the MCDA-framework for a
194 NZ-specific context (Langhans & Schallenberg, 2022).

195 A defining characteristic of the MCDA-framework is that it describes an inclusive,
196 transparent, collaborative step-by-step process, whereby multiple local interest groups
197 (stakeholders) have equal opportunity for input into the process (see Langhans, Jähnig, &
198 Schallenberg, 2019; Langhans & Schallenberg, 2022 for a discussion of how Māori might want to
199 collaborate on, or use the framework). The subjective value preferences of said stakeholders and
200 objective expert knowledge ('expert knowledge' as discussed in Burgman et al. (2011)) are clearly
201 separated throughout the process, but are ultimately combined to identify the management actions
202 that have the most buy-in from all stakeholders. The first step of the MCDA-framework is to
203 identify key stakeholders (Langhans et al., 2019; Langhans & Schallenberg, 2022). Key stakeholder
204 groups which would be identified with an *ad hoc* a priori-approach based on visible activities in the
205 Blueskin catchment and estuary include forestry, commercial cockle harvest, housing development,
206 tourism, and recreational/customary bivalve harvest.

207

208 Development of the management objectives hierarchy

209 During the four workshops, the Blueskin Bay community defined the main objective as “[the
210 establishment of] a collaborative catchment-estuary management plan (including estuary restoration
211 and conservation) that recommends priority actions to maintain and/or restore the chemical,
212 physical, and biological integrity of the estuary and its catchment while allowing for sustainable use
213 of its ecosystem services”. The main objective was separated into five first-level objectives (Fig.
214 2A): (1) effect excellent catchment and estuary health, (2) maintain sense of place in a changing and
215 dynamic environment, (3) maintain local culture, (4) allow for sustainable economic activities, and

216 (5) adaptability to climate change. Each of the first-level objectives was divided into more specific
217 second-level objectives including: (1.1) effect excellent estuary health and (1.2) effect excellent
218 catchment health (both under the first-level objective ‘catchment and estuary health’); (2.1)
219 maintain or restore native water-bound bird populations, (2.2) no invasive species, (2.3) maintain or
220 restore functioning and native estuary riparian vegetation, and (2.4) maintain protective spit
221 vegetation (under ‘sense of place’); (3.1) preserve indigenous knowledge, (3.2) ensure satisfactory
222 experience harvesting mahinga kai, and (3.3) ensure satisfactory experience with recreational
223 activities (under ‘local culture’) (Fig. 2B); (4.1) establish or maintain sustainable cockle harvest,
224 (4.2) sustainable agriculture, (4.3) sustainable forestry, (4.4) sustainable tourism, and (4.5)
225 sustainable urbanization (under ‘economic activities’) and, finally, (5.1) implement cost-effective
226 monitoring and (5.2) cost-effective management action (under ‘cost-effective management plan’)
227 (Fig. 2C). The second-level objectives were further refined into third and fourth level objectives
228 (Fig. 2A-C).

229

230 Identifying the community’s weight preferences for various management objectives

231 Instead of interviewing one or only a few representative(s) of each a priori-defined key stakeholder
232 group (as it is usually done in collaborative management; Harris-Lovett, Lienert, & Sredlak, 2019;
233 Langhans & Schallenberg, 2022; Marttunen, Weber, Aberg, & Lienert, 2019), we interviewed 36
234 adults who are working or living in proximity to the Blueskin Bay estuary to elicit individuals’
235 weights for different management objectives. We aimed at interviewing people working in, or
236 having links to, all the industries present in the Blueskin Bay catchment including cockle harvest,
237 forestry, and construction/housing developers as well as community members not depending on
238 economic activity directly related to Blueskin estuary. To cover all the industries, we actively
239 approached potential participants. Additional community participants were gathered through word
240 of mouth and an interview sign-up sheet provided in the local public library. Everybody who was
241 interested in participating was interviewed.

242 Interviews were performed during October 2020, face-to-face with each participant
243 individually, following a standardised protocol to minimise biases due to framing, availability and
244 social context (Burgman et al., 2011). Standardised interview protocols also minimised interviewer
245 error and ensured participants were asked identically worded questions without unscripted
246 commentary that could bias the answers (Fowler & Mangione, 1990). A template of the interview
247 questions used is provided on zenodo <https://doi.org/10.5281/zenodo.6821332>.

248 Interviews were based on a method which is commonly used to elicit weight preferences
249 called the Swing-method (Eisenführ et al., 2010). With the Swing-method one asks interviewees to
250 assign points from 0 to 100 to hypothetical management scenarios, each of which results in the

251 complete restoration of one of the pre-defined management objectives, while all the other objectives
252 in the same branch remain in an unfulfilled condition. The points are assigned relatively to a worst-
253 case scenario (with all objectives in the same branch being in the unfulfilled condition; receiving
254 zero points) and to a best-case scenario in which the interviewee's most important objective is
255 restored to the best condition (receiving 100 points). For example, in our case when eliciting
256 community weights for the first-level objectives (Fig. 2A), the worst-case scenario for a
257 collaborative catchment-estuary management plan for Blueskin Bay estuary (Fig. 2A, main goal)
258 was that all five first-level objectives remain unfulfilled. This scenario always received zero points
259 for all interviewees. The interviewer then asked the interviewee to name their most important first-
260 level objective. Let's assume for interviewee x this was "effect excellent catchment and estuary
261 health". Hence, a hypothetical management scenario that improves the objective on 'catchment and
262 estuary health' to the best condition, while all other first-level objectives remain unfulfilled,
263 received 100 points for interviewee x. Then, interviewee x identified their second most important
264 first-level objective and assigned points between 0 and 100 to a management scenario that improves
265 said second most important first-level objective to the best condition, while all other first-level
266 objectives remain unfulfilled. This process included the third, fourth and least important first-level
267 objective with the interviewee, and was repeated for all second-level objectives
268 (<https://doi.org/10.5281/zenodo.6821332>).

269 The points given by the interviewees were then transferred into weights according to
270 equation 1 (Eisenführ et al., 2010):

271 (1)
$$w_r = \frac{t_r}{\sum_{i=1}^m t_i}$$

272 where

273 w_r = weight of objective X_r

274 t_r = points given to objective X_r

275 m = number of objectives.

276

277 For the purpose of defining weights for decision-making in the environmental sector, Lienert et al.
278 (2011) adapted the Swing-method to a reverse version, which they found was more intuitive
279 for interviewees to follow. However, when we trialed the interview protocol in the Blueskin Bay
280 area, the Reverse Swing-method was assessed as less intuitive, and we switched back to working
281 with the original method.

282

283 Identifying value-preferences groups for management objectives

284 To identify groups of similar value preferences among the 36 interviewed community members, we
285 applied cluster analysis (Hastie, Tibshirani, & Friedman, 2009) – a statistical method which is part
286 of the pattern recognition/ unsupervised machine learning family. We performed agglomerative
287 hierarchical clustering with two separate analyses, one based on the stated preferences for the first-
288 level management objectives and another one for the second-level objectives using the software R
289 (R Core Team, 2020) and the package ‘cluster’ (Maechler et al., 2016). Similarity between
290 participants’ preferences was determined by Ward’s agglomerative clustering algorithm (Ward.D2
291 = Ward’s minimum variance method; Ward, 1963). This algorithm is based on a classical sum-of-
292 squares criterion producing groups that minimize within-group dispersion at each point where two
293 groups merge and looks for clusters in a multivariate two-dimensional space (Murtagh & Legendre,
294 2014). A weaknesses of Ward’s method is that the algorithm is constrained by previous choices.

295 As identifying the “correct” number of clusters has been shown to be difficult in real-world
296 applications (Dash, Liu, Scheuermann, & Tan, 2003), we applied a two-step approach: First, we
297 plotted separate dendrograms for the stated preferences for the first- and second-level objectives
298 and identified the number of clusters visually based on the dendrograms’ hierarchical structure. For
299 each pair of dendrograms produced, we selected a distance along the dendrograms’ y-axis where the
300 distance between clusters was greatest. Then to validate the selection, we ran NbClust which uses
301 30 different indices for determining the number of clusters (Charrad, Ghazzali, Boiteau, & Niknafs,
302 2015).

303

304 **Results**

305 *Descriptives of interviewed community members*

306 The 36 interviewed community members comprised 19 women and 17 men between the ages of 29
307 and 76. For cultural heritage, three of the 36 people identified as Māori, one as Indigenous
308 Canadian and 32 people identified as NZ European.

309

310 *Participants value-preference clusters of first-level objectives*

311 Based on the preferences elicited for the first-level objectives, the agglomerative hierarchical cluster
312 analysis grouped the 36 community members into four distinct clusters of different sizes: cluster 1.1
313 had seven individuals, cluster 1.2 had one individual, cluster 1.3 had six individuals, cluster 1.4 had
314 22 individuals (Fig. 3). Through a visual analysis of each cluster’s preferences and comparisons to
315 those of the other clusters (Table 1A), cluster 1.1 exhibited high weightings for the objective
316 ‘catchment and estuary health’ paired with low weights for the objectives ‘sustainable economic
317 activities’ and ‘cost-effective catchment management plan’ (and consequently higher weightings for
318 ‘local culture’). Cluster 1.2 exhibited a high weighting for the objective ‘sustainable economic

319 activities', cluster 1.3 high weightings for the objective 'catchment and estuary health' paired with
320 low weightings for the objective 'local culture', and cluster 1.4 exhibited relatively evenly
321 distributed weightings for all five first-level objectives. Based on the weightings apparent for the
322 identified clusters, the stakeholder types identified by the cluster analysis were termed Cultural
323 Environmentalists, Industry stakeholder (Forestry), Economic Environmentalists and Diverse
324 Interests stakeholders, respectively for clusters 1.1 to 1.4.

325

326 *Value-preference clusters of second-level objectives*

327 Based on the stakeholders' preferences elicited for the second-level objectives, the cluster analysis
328 grouped participants into five distinct clusters with three clusters consisting of one individual each
329 (clusters 2.1, 2.2 and 2.4), cluster 2.3 with 25 individuals and cluster 2.5 consisting of eight
330 individuals (Fig. 4). The three Clusters with one member were characterized by: cluster 2.1 - a full
331 weighting given to the objective 'sustainable tourism' (i.e., zero weighting given to the three other
332 second-level objectives in the 'sustainable economic activities' branch), cluster 2.2 - a high
333 weighting for 'sustainable urbanization' paired with a low weighting for 'no invasive species' and
334 no weighting given to 'cost-effective management plan' and, cluster 2.4 - a high weighting for
335 'sustainable cockle harvest' and zero weighting for 'protective spit vegetation'. Cluster 2.3 was
336 characterized by evenly distributed weightings across the second-level objectives and cluster 2.5 by
337 particularly high weightings for 'indigenous knowledge preservation' and higher weightings for
338 'catchment health' than for 'estuary health' (Table 1B). Based on the weightings, the stakeholder
339 types in the clusters were termed Industry stakeholder (Tourism), Urban Development Advocates,
340 Diverse Interests stakeholders, Industry stakeholder (Commercial Cockle Harvest) and Integrative
341 Thinkers, respectively for clusters 2.1 to 2.5.

342

343 *Comparison of clusters' composition at the two levels of management objectives*

344 We performed a simple network analysis to compare the composition of clusters between the two
345 levels of management objectives (Fig. 5). Representatives of the Cultural and Economic
346 Environmentalists were distributed between four and three different stakeholder types on the second
347 level of objectives, respectively, while only a small fraction of the Diverse Interests stakeholders
348 were attributed to a new type (to the Integrative Thinkers; 4 out of 22 individuals) at the second
349 level. The representative of the Industry stakeholder type chose similar weights for all objectives at
350 the second level and, consequently, grouped with the Diverse Interests stakeholders.

351

352 **Discussion**

353 Public participation, including the collaboration of researchers, local experts, decision makers, and
354 the general public, is becoming a standard feature of environmental decision making. This trend is
355 mirrored in 21st century legislation as well as large research programs (e.g. Horizon Europe;
356 <http://ec.europa.eu/horizon-europe>), which mandate public engagement as an element in
357 environmental management research projects and actions. Despite best practice handbooks
358 emphasizing the importance of stakeholder selection (Durham et al., 2014; European Commission,
359 2003), identifying relevant stakeholder groups is still often done a priori or *ad hoc* when selected
360 key stakeholders are not available for participation. This is surprising, since recent evidence
361 suggests that the particular participants in collaborative catchment management processes can
362 considerably influence their outcomes (Baudoin & Gittins, 2021; Koontz & Johnson, 2004).
363 Consequently, acquiring a good understanding of the value preferences-landscape is key to ensure
364 representatives of all value preferences-groups that are locally and thematically relevant are
365 included in a collaborative management process.

366 We tested a hierarchical cluster analysis approach in the Blueskin Bay area specifically for
367 the community's weightings of management objectives that they had previously identified as being
368 of relevance for the management of Blueskin Bay catchment and estuary. We found preference
369 clusters reflecting the following stakeholder types: those showing commercial interests (e.g., cockle
370 harvesting, tourism and forestry; the Industry Stakeholders), Sustainable Urban Development
371 Advocates, Cultural Environmentalists, Economic Environmentalists, Integrative Thinkers and
372 stakeholders with Diverse Interests. While community members with local economic interests were
373 primarily (but not only) concerned with objectives directly related to their industries, the cluster
374 analyses revealed additional groups with distinct, non-economic interests in the area. A similar
375 result was found by Pascoe et al. (2009) who elicited stakeholder preferences for objectives of
376 marine fisheries management in Australia. They found that while stakeholder preferences generally
377 corresponded with their expected preference set, there was low coherence within stakeholder
378 groups. Interestingly, in our study not all representatives of the Industry stakeholder type had a
379 direct link to one of the local businesses. This result showcases that people's preferences are not
380 necessarily motivated by personal economic benefits, even when advocating for sustainable
381 economic activities.

382 At both levels of management objectives, we found a small cluster representing commercial
383 interests (Industry Stakeholders) as well as a large cluster of participants who weighted all
384 objectives at the respective level similarly (Diverse Interests Stakeholders). These common clusters
385 were supplemented by two small clusters identified at each level of objectives (Fig. 5): At the first
386 level, the two additional stakeholder types were clustered based on strong preferences for
387 environmental management objectives, with one focusing on cultural objectives and the other one

388 on economic objectives; preference clusters at the second level of objectives revealed an additional
389 stakeholder type that advocates for sustainable urban development and one with strong preferences
390 for approaching estuary management in an integrative way regarding the spatial scale (catchment)
391 and the information sources that are used (indigenous knowledge). This pattern, composed of one
392 large value preference cluster and multiple smaller ones, was also found for a river restoration study
393 in Germany, in which the majority of people who use the river environment for recreational
394 activities had contrasting value preferences compared to smaller user groups (Symmank, Profeta, &
395 Niens, 2021). In our case study, a possible explanation for the large diverse interests clusters might
396 have been social learning (Luyet et al., 2012), whereby community members developed a better
397 understanding and therewith empathy towards the whole range of objectives due to their previous
398 participation in the workshop series.

399 Comparing all of the above stakeholder types with the activities which we had identified a
400 priori to be relevant for the main goal of ‘establishing a collaborative catchment-estuary
401 management plan’ (i.e. forestry, commercial cockle harvest, housing development, tourism and
402 recreational/customary bivalve harvest), clearly illustrated a more complex value preferences-
403 landscape that transcended pre-conceptions of a priori stakeholder interests based on visible
404 activities in the case study area. Consequently, the use of an analytical hierarchical cluster analysis
405 approach, as we have tested here, shows merit to become a promising addition to the currently used
406 methods, such as focus groups, snowball-sampling, interest-influence matrices, stakeholder-led
407 stakeholder categorization or Q methodology (see in-depth discussion of these methods in Reed,
408 2009) and, therewith, to help towards alleviating the problem of under-representing marginalized or
409 powerless groups in environmental management decision-making processes. By identifying
410 community preferences, not only for the broad first-level management objectives but also for the
411 more specific objectives at the second-level, we revealed additional preference clusters. Future
412 research will have to investigate how much new knowledge on a community’s value preferences-
413 landscape can be gained by analyzing more specific levels of objectives (e.g. in our case 3rd and 4th;
414 Fig. 2).

415 We acknowledge some weaknesses of this study, including the total number of participants,
416 their ethnical diversity, their age distribution as well as their personal attitude and interest towards
417 environmental issues in the area. The local population size is approximately 1000 people (Statistics
418 New Zealand, 2020) of which we interviewed 36. This is a relatively small number despite the
419 intensive recruitment effort we made. One potential reason for the low participation is the covid-19
420 pandemic, which was shown to lead to a decrease in pro-environmental behavior during periods of
421 lockdown restrictions (Kesenheimer & Greitemeyer, 2021) and has likely decreased willingness to
422 contribute to pro-environmental activities in the case study area as well. Along the same lines, the

423 study would have benefitted from the participation of more younger community members and
424 people of Māori heritage. Finally, one of the *a priori* identified stakeholders, the housing
425 developers, were not interested in participating in the study. Hence, we missed aspects of the value-
426 preferences landscape which would have contributed to our analysis. Accordingly, we recommend
427 accounting for the possibility that recruitment of some community groups will take extra resources,
428 especially for those groups which are unfamiliar with, or are not interested in environmental
429 management.

430 In future applications of the approach, it has to be taken into account that when interviews
431 are performed face-to-face, the analytical cluster analysis-approach is more time-consuming and
432 resource-intense compared to interviewing a limited set of *a priori* identified stakeholders. To
433 resolve this issue, interviews could be conducted face-to-face over a streaming platform or with
434 online questionnaires, which could be filled out by participants in their own time. Driven by NZ's
435 covid-19 response, we trialled both approaches in the Blueskin Bay area but without success.
436 Consequently, from our experience, choosing an interview set-up which is adapted to local
437 circumstances, people's comfort zones and their tech-related abilities is essential to collecting
438 robust values-preference data.

439

440 **Conclusions**

441 We found that using hierarchical cluster analyses provides the means to analytically disclose value-
442 preference groups that do not strictly align with assumed stakeholder value preferences in the
443 context of water management decision-making. Consequently, cluster analysis clearly helps identify
444 more nuanced perspectives which are likely missed when selecting stakeholders in the usual *a*
445 *priori* manner and, therewith, increases the robustness of collaborative restoration and management
446 processes such as the one underway for Blueskin Bay's catchment and estuary. The weight
447 preferences identified for the different clusters can be fed back into the MCDA-framework
448 (Langhans et al., 2019; Langhans & Schallenberg, 2022) where they, paired with predicted
449 consequences of potential management actions, build the basis for optimising a management plan
450 that includes the values landscape of the whole Blueskin Bay community and, therefore, will be
451 truly collaborative. Future research needs to test the analytical cluster analysis-approach for
452 different community sizes, locations with different cultural backgrounds and for environmental
453 planning processes dedicated to different problem framings, to get a more nuanced picture of the
454 main drivers of community values landscapes.

455

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465

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468

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475

476 **Data Availability Statement**

477 The interview protocol for the elicitation of community preferences that support the findings of this
478 study are openly available in zenodo at <https://doi.org/10.5281/zenodo.6821332>.

479

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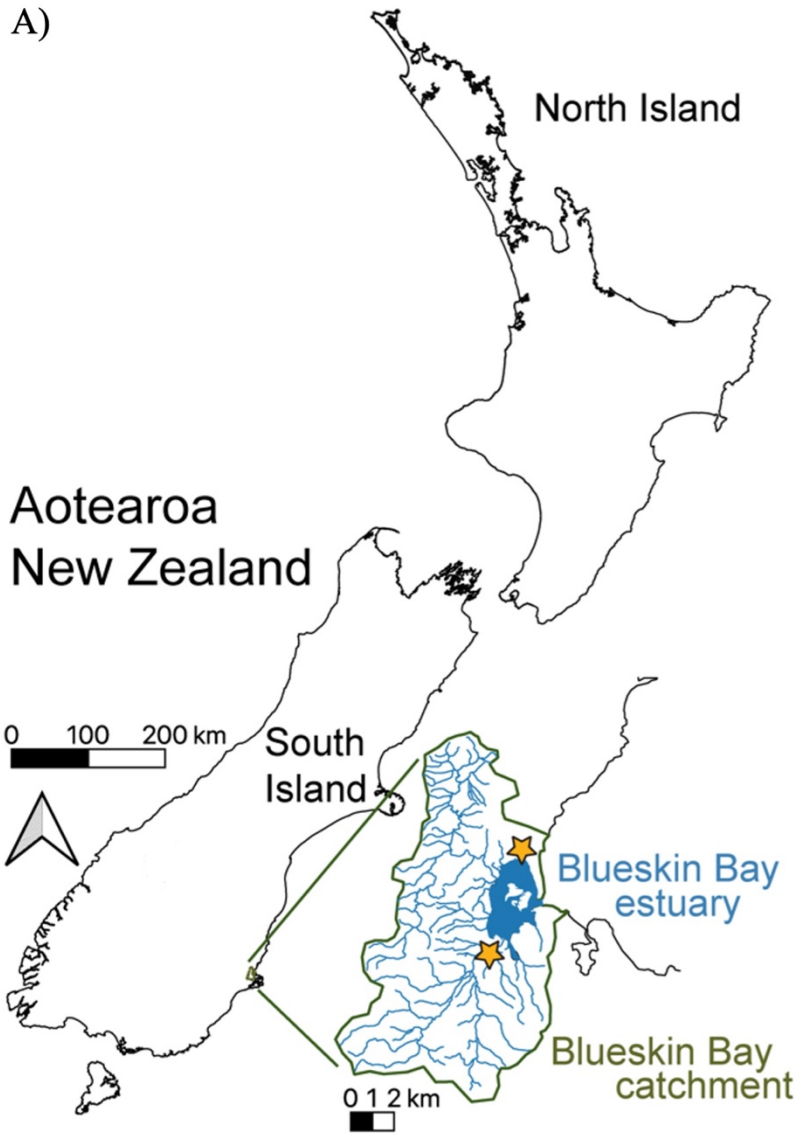
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670

671 **FIGURE CAPTIONS**

672

673 **Figure 1. Map of the study area.** A) The Blueskin Bay estuary and its catchment located on the
674 east coast of Otago in the South Island of Aotearoa/New Zealand; B) bird's-eye view of the estuary
675 at high tide with enhanced coloring to show differing water levels; C and D) collection of shellfish
676 (cockles – *Austrovenus stutchburyi*) at low tide; and E) extensive growth of the sea lettuce (*Ulva*
677 sp).



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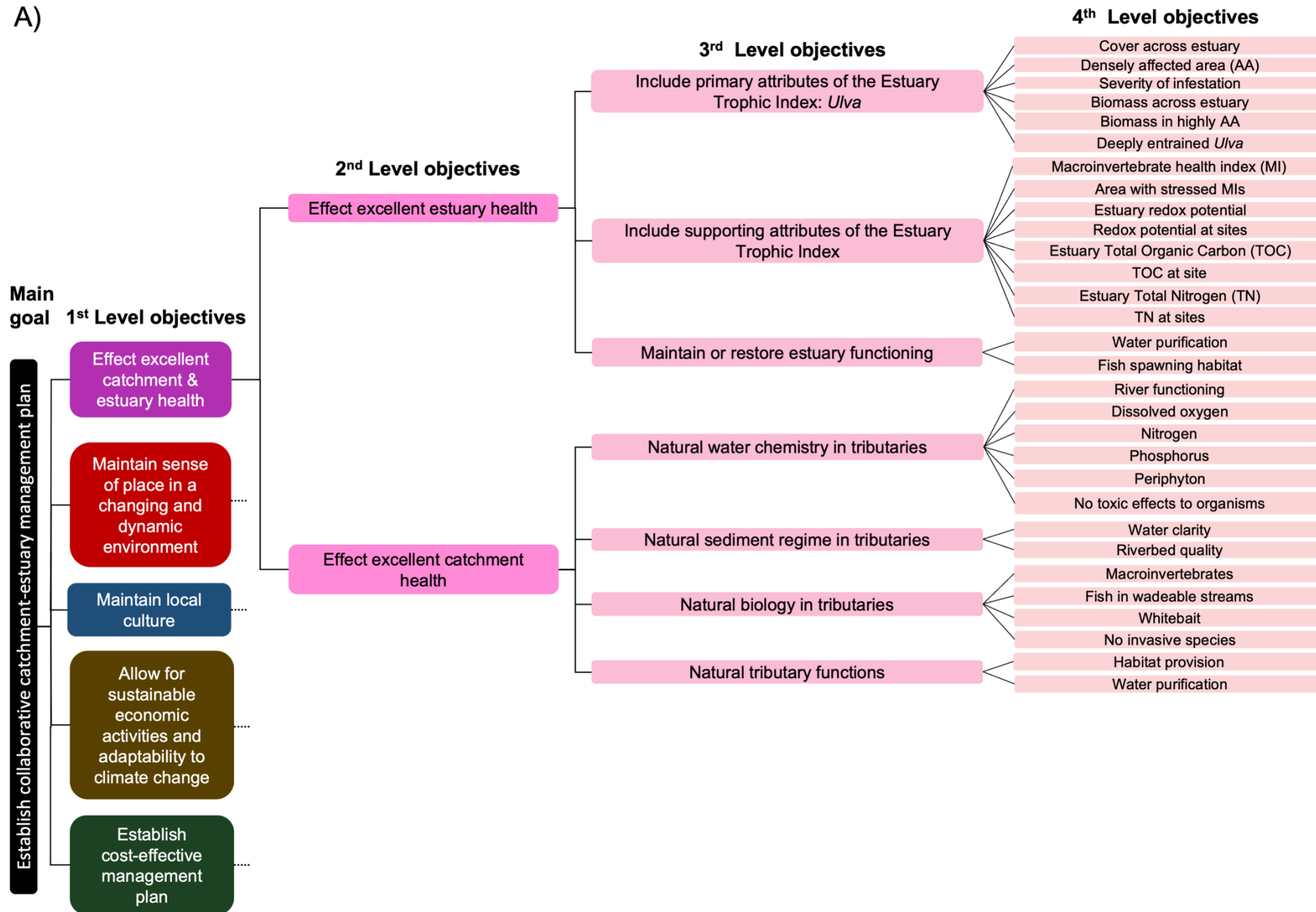
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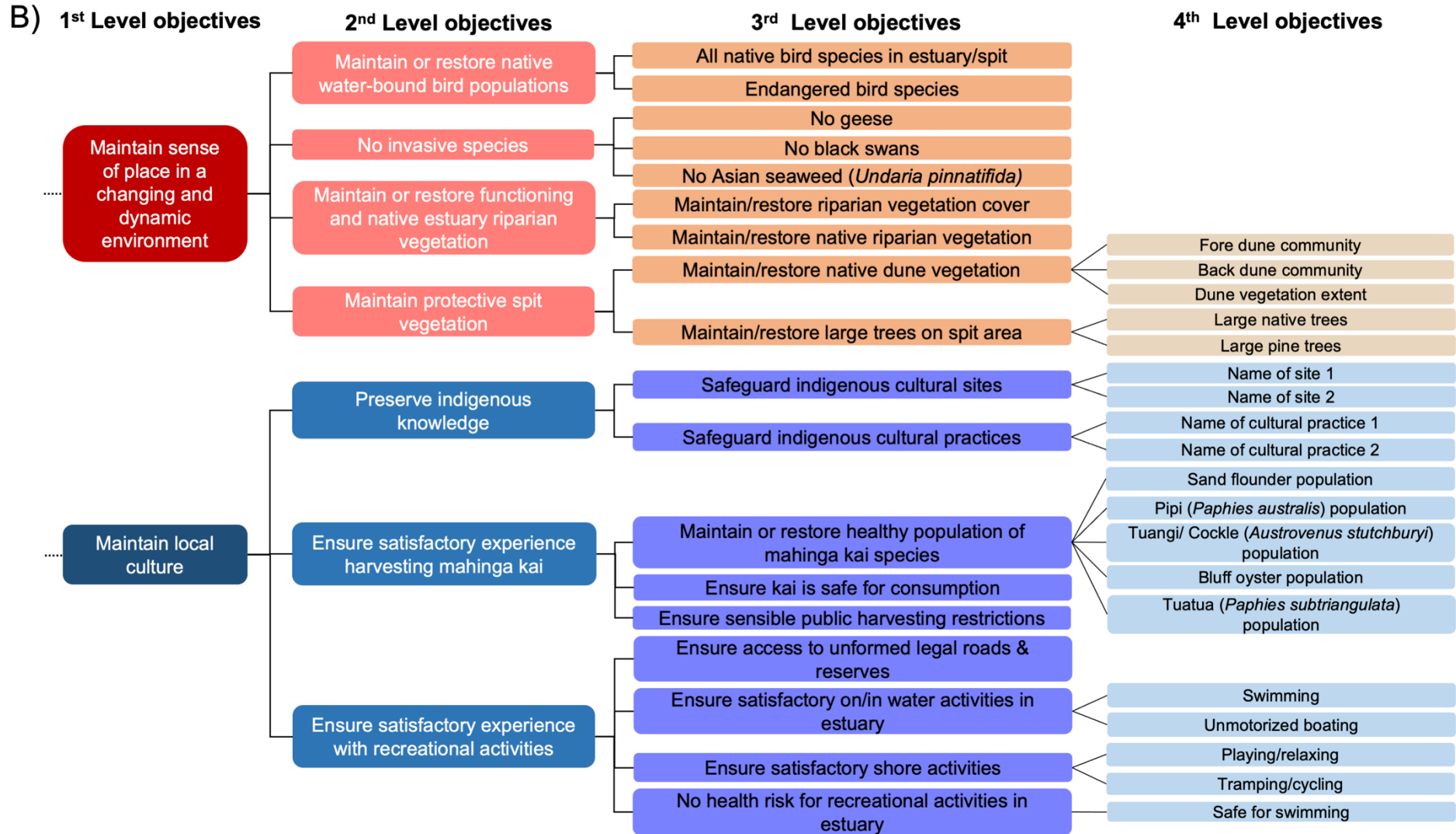
681 **Figure 2. Hierarchy of management objectives for the Blueskin Bay estuary and its upper**
682 **catchment.** A) Overall objective, all first level objectives and sub-objectives for *effecting excellent*
683 *catchment and estuary health*; B) sub-objectives for *maintaining sense of place in a changing and*
684 *dynamic environment and maintaining local culture*; and C) sub-objectives for *allowing for*
685 *sustainable economic activities and adaptability to climate change* and *establishing cost-effective*
686 *management plan*. The objectives hierarchy was elicited from local residents during four
687 consecutive facilitated workshops that took place throughout 2019. All workshops had 40 to 60
688 participants.

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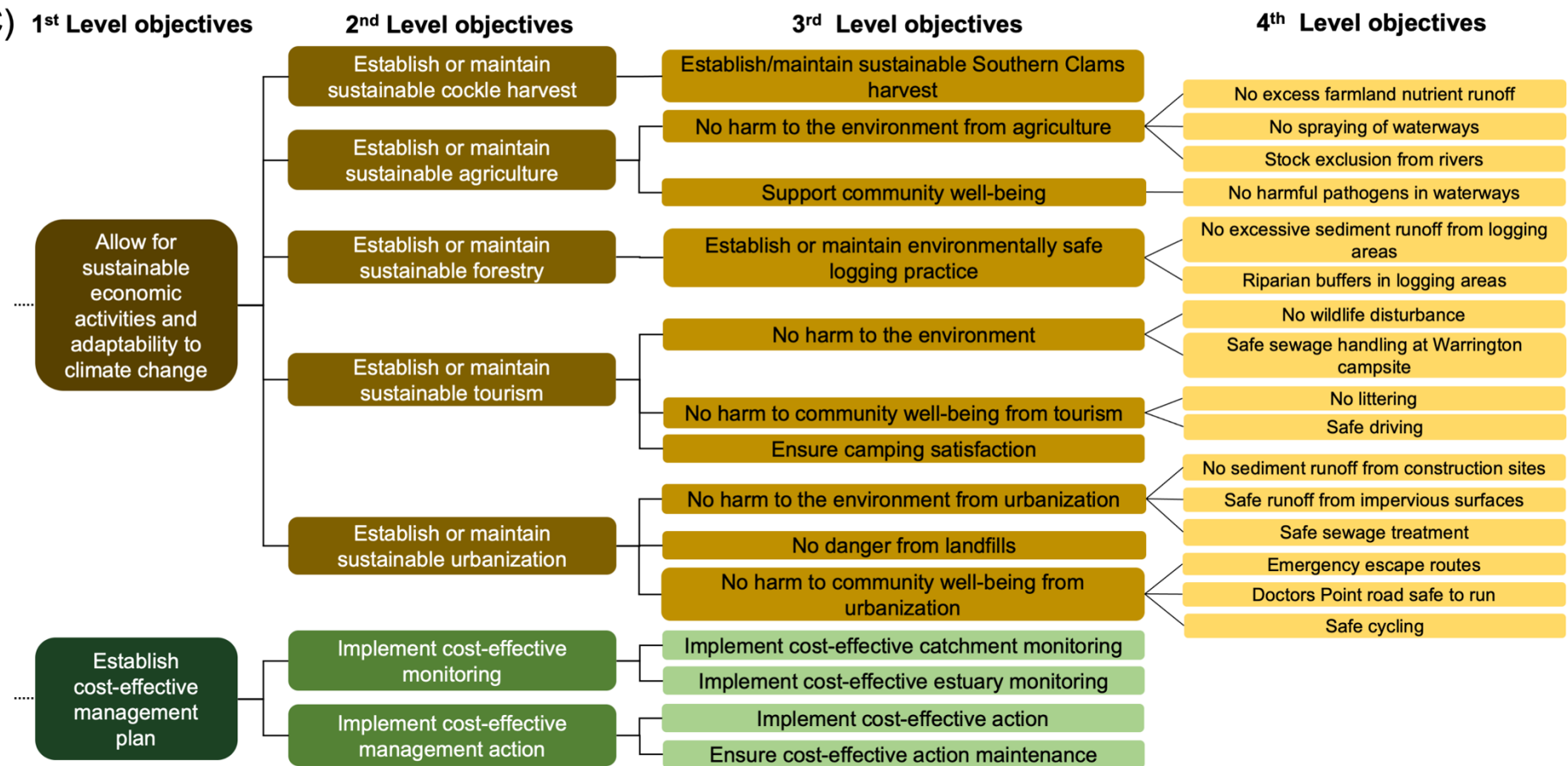
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A)

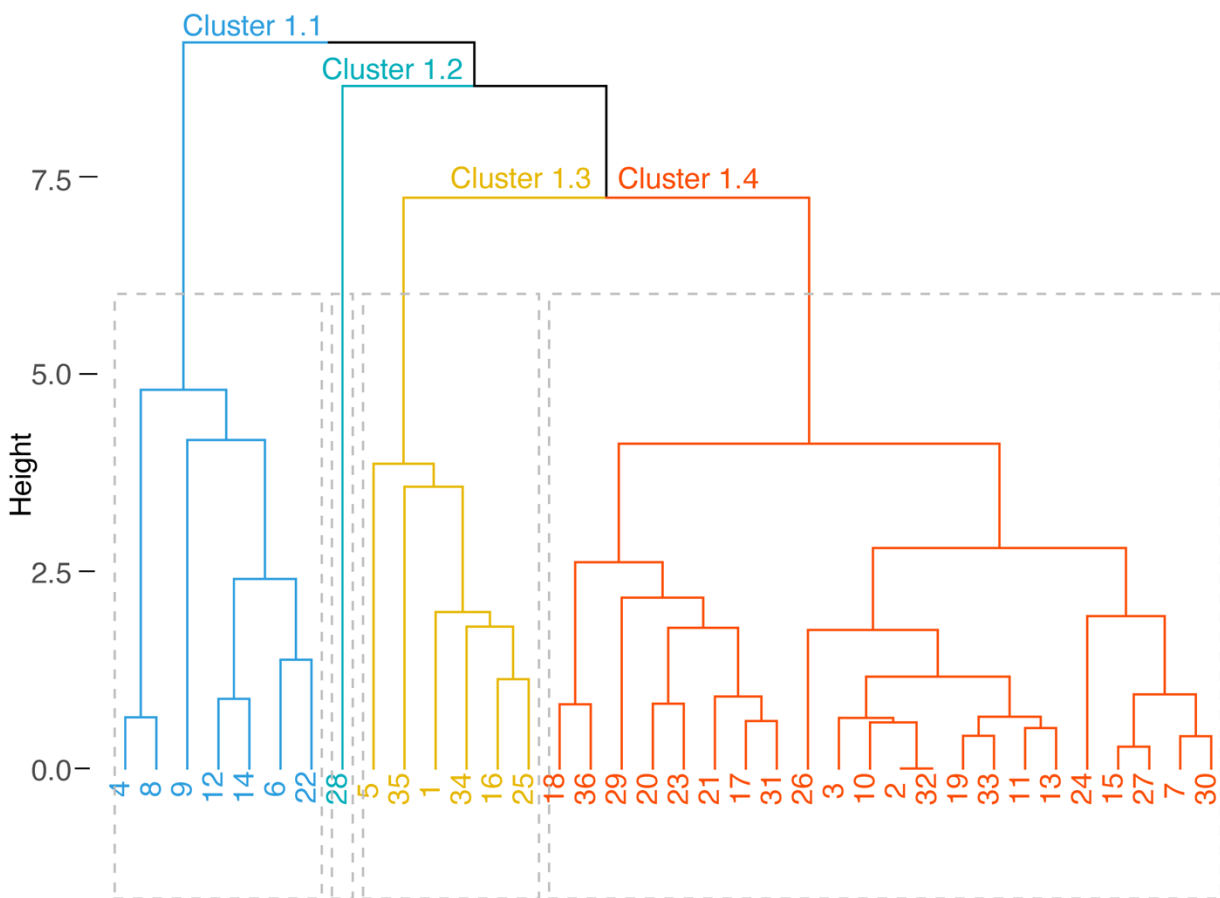




C) 1st Level objectives

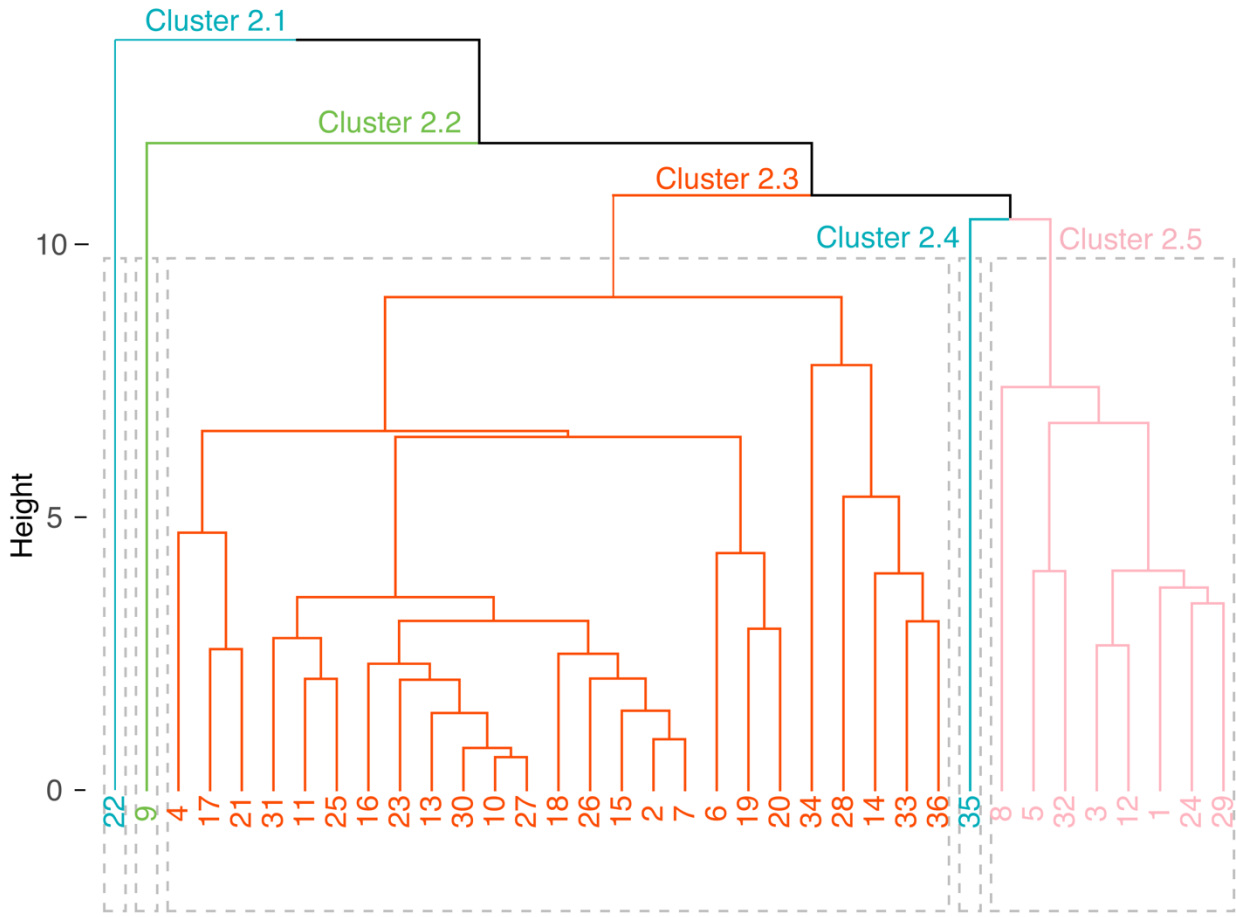


694 **Figure 3. Dendrogram for the 1st-level management objectives.** The dendrogram represents the
 695 clusters generated by the Ward.D2 agglomerative clustering algorithm based on the interviewees' (1
 696 to 36 on the x-axis) preferences of the first-level objectives identified to be relevant for the
 697 management of Blueskin Bay estuary and its upper catchment. Each cluster represents a stakeholder
 698 type. A dendrogram is a two dimensional diagram that depicts how the agglomeration is done at the
 699 different stages of the cluster analysis. The Y-axis depicts the distance among the ratings while the
 700 X-axis lists the participants. Clusters with the same color represent the same stakeholder types as in
 701 Fig. 4.
 702



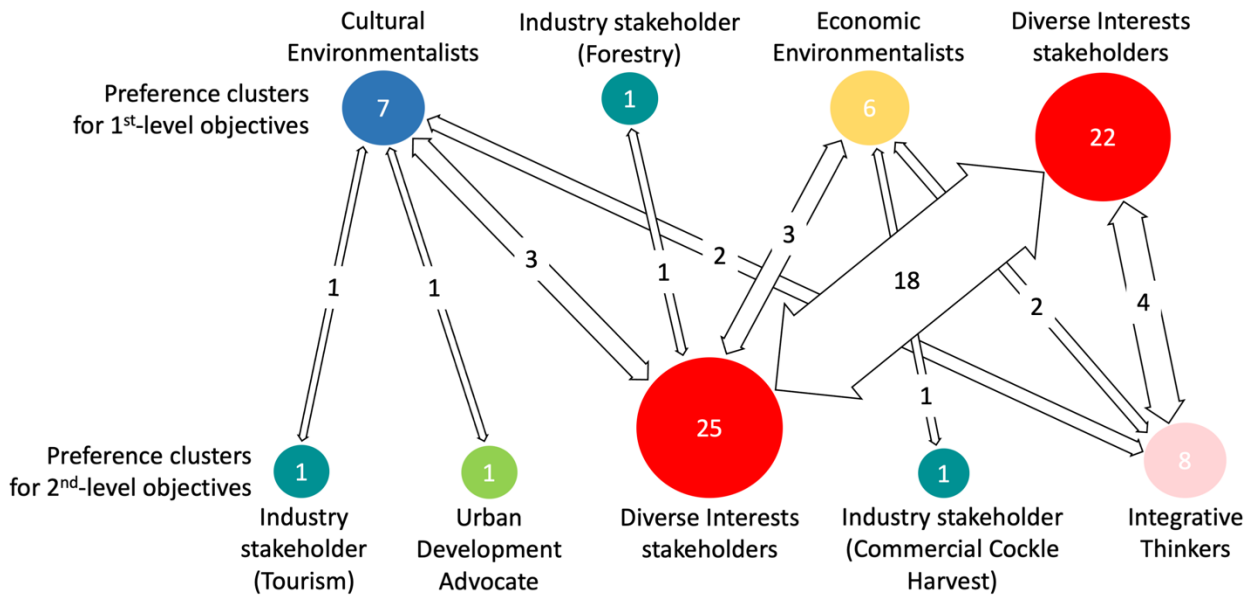
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705 **Figure 4. Dendrogram for the 2nd-level management objectives.** The dendrogram represents the
 706 clusters generated by the Ward.D2 agglomerative clustering algorithm based on the interviewees'
 707 preferences (1 to 36 on the x-axis) of the second-level objectives identified to be relevant for the
 708 management of Blueskin Bay estuary and its upper catchment. Clusters with the same color
 709 represent the same stakeholder type, also when compared to Fig. 3.



710
 711

712 **Figure 5. Comparison of clusters' composition at the two levels of management objectives.**
 713 Circles represent clusters and stakeholder types identified through cluster analyses, with colors
 714 corresponding to dendrograms in Figs. 3 and 4. Numbers within circles indicate numbers of
 715 interviewees comprising a cluster. Numbers within arrows indicate how many interviewees share
 716 preferences for the connected clusters.



717

718 **TABLES**

719 **Table 1. Weight preferences for pre-defined management objectives.** A) First-level objectives; B) second-level objectives. Weights were elicited
 720 with the Swing-method from the 36 interviewed community members. Weights sum up to 100. ID = identification number of the interviewee; CEH =
 721 catchment and estuary health; SOP = sense of place; LC = local culture; SEA = sustainable economic activities; CEM = cost-effective management
 722 plan; Est = estuary health; Catch = catchment health; Birds = water birds; Inv spec = no invasive species, Rp veg = estuary riparian vegetation, Spit veg
 723 = protective spit vegetation, IK pres = indigenous knowledge preservation; Mah kai = harvesting mahinga kai; Rec act = recreational activities; Cockle
 724 = sustainable cockle harvest; Agr = sustainable agriculture; For = sustainable forestry; Tour = sustainable tourism; Urb = sustainable urbanization;
 725 Mon = cost-effective monitoring; Act = cost-effective management action. Ordering of the IDs and color coding correspond to clusters and colors in
 726 Figures 3 and 4.

727 A)

728 ID	Catchment & estuary health	Sense of place	Local culture	Sustainable economic activities	Cost-effective management
731 4	27.8	19.4	22.2	27.8	2.8
732 8	27	21.6	21.6	27	2.7
733 9	33.4	30.1	33.1	3.3	0
734 12	33.3	23.3	23.3	10	10
735 14	29.9	23.9	23.9	13.4	9
736 6	28.6	28.6	17.1	11.4	14.3
737 22	31.3	25	18.8	6.3	18.8
738 28	28.6	2.9	8.6	57.1	2.9
739 5	25	25	5	20	25
740 35	26.7	6.7	6.7	33.3	26.7

741	1	32.3	12.9	9.7	19.4	25.8
742	34	29.9	17.9	11.9	22.4	17.9
743	16	25.6	15.4	19.2	19.2	20.5
744	25	27	13.5	13.5	21.6	24.3
745	18	24.7	17.3	24.7	12.3	21
746	36	26.3	18.4	21.1	13.2	21.1
747	29	25.7	20	28.6	17.1	8.6
748	20	19.5	24.4	24.4	17.1	14.6
749	23	22.7	22.7	22.7	18.2	13.6
750	21	25.6	23.1	20.5	15.4	15.4
751	17	25	20	22.5	17.5	15
752	31	25	20	20	20	15
753	26	18.2	20.5	15.9	22.7	22.7
754	3	22.2	22.2	20	17.8	17.8
755	10	21.7	19.6	21.7	17.4	19.6
756	2	21.7	19.6	19.6	19.6	19.6
757	32	21.7	19.6	19.6	19.6	19.6
758	19	20.2	20	20	20	20
759	33	19.1	21.3	19.1	21.3	19.1
760	11	19.9	21.6	20.6	18.4	19.5
761	13	20	20	22.2	20	17.8
762	24	24.2	15.2	15.2	30.3	15.2
763	15	24.7	18.5	18.5	19.8	18.5

764	27	23.8	19	19	19	19
765	7	22.2	17.8	17.8	22.2	20
766	30	22.7	18.2	18.2	22.7	18.2

767

768 B)

769	ID	Est	Catch	Birds	Inv spec	Rip veg	Spit veg	IK pres	Mah kai	Rec act	Cockle	Agr	For	Tour	Urb	Mon	Act
770	22	44.4	55.6	10	40	20	30	31.6	52.6	15.8	0	0	0	100	0	50	50
771	9	47.4	52.6	22.2	3.7	37	37	33.3	33.3	33.3	13.6	13.6	13.6	13.6	45.5	0	0
772	4	55.6	44.4	26.3	23.7	23.7	26.3	33.3	33.3	33.3	30.3	3	6.1	30.3	30.3	33.3	66.7
773	17	54.1	45.9	21.4	28.6	21.4	28.6	32.3	35.8	31.9	26.3	22.4	13.2	15.8	22.2	50	50
774	21	52.6	47.4	25	25	25	25	33.3	33.3	33.3	21.9	31.3	15.6	12.5	18.8	37.5	62.5
775	31	49.7	50.3	25	18.8	31.3	25	30.8	30.8	38.5	20	25	15	20	20	50	50
776	11	49.7	50.3	29.2	15.4	30.8	24.6	34.9	35.2	29.9	22.4	22.2	20.6	13.5	21.3	50	50
777	25	50	50	24.2	21.2	30.3	24.2	32.1	35.7	32.1	29.4	26.5	23.5	8.8	11.8	50	50
778	16	50	50	23.5	23.5	29.4	23.5	34	37.7	28.3	14.3	20	17.1	28.6	20	52.6	47.4
779	23	50	50	25	25	25	25	33.3	33.3	33.3	20	20	20	20	20	62.5	37.5
780	13	50	50	29.4	20.6	23.5	26.5	33.3	33.3	33.3	21.3	21.3	19.1	19.1	19.1	52.6	47.4
781	30	50	50	25	25	25	25	33.3	33.3	33.3	19.6	21.7	19.6	19.6	19.6	50	50
782	10	50	50	25	25	25	25	34.5	34.5	31	20.4	19.4	1.4	20.4	20.4	51.3	48.7
783	27	50	50	25	25	25	25	35.7	32.1	32.1	22.2	17.8	20	20	20	50	50
784	18	48.7	51.3	25.1	25.4	24.9	24.6	35.2	34.9	29.9	28.6	11.4	14.3	25.7	20	47.4	52.6
785	26	47.4	52.6	25.7	28.6	22.9	22.9	40	28	32	19.6	19.6	19.6	19.6	21.7	52.6	47.4
786	15	47.4	52.6	25.4	25.4	28.2	21.1	37	29.6	33.3	24.1	19.3	19.3	18.1	19.3	47.4	52.6

787	2	47.4	52.6	25	22.2	27.8	25	32.1	32.1	35.7	20.5	18.2	18.2	22.7	20.5	50	50
788	7	48.7	51.3	23.3	24.7	27.4	24.7	34.5	31	34.5	20.4	18.3	19.4	20.4	21.5	48.7	51.3
789	6	50	50	32.3	22.6	22.6	22.6	30.8	30.8	38.5	47.6	23.8	14.3	14.3	0	55.6	44.4
790	19	49.7	50.3	26.8	21.7	27.1	24.2	34.6	34.3	31.1	33.7	34	8.5	6.8	17	49.7	50.3
791	20	47.4	52.6	24.3	24.3	27	24.3	35.7	35.7	28.6	31	27.6	3.4	34.5	3.4	50	50
792	34	58.8	41.2	25.9	11.1	37	25.9	15.8	52.6	31.6	23.8	15.9	12.7	31.7	15.9	41.2	58.8
793	28	47.4	52.6	21.7	13	43.5	21.7	22.7	45.5	31.8	14.7	20.6	29.4	11.8	23.5	44.4	55.6
794	14	50	50	24.6	23.1	30.8	21.5	25.9	37	37	0	24.6	26.2	16.4	32.8	33.3	66.7
795	33	50	50	25	25	25	25	32.8	34.5	32.8	3.1	31.3	25	25	15.6	44.4	55.6
796	36	50	50	35.7	17.9	17.9	28.6	30.8	38.5	30.8	11.4	22.9	28.6	17.1	20	41.2	58.8
797	35	47.4	52.6	48.8	2.4	48.8	0	33.3	33.3	33.3	27	13.5	21.6	16.2	21.6	50	50
798	8	50	50	32.3	16.1	25.8	25.8	50	25	25	8.3	41.7	8.3	8.3	33.3	66.7	33.3
799	5	44.4	55.6	28.6	35.7	21.4	14.3	45.5	18.2	36.4	33.3	26.7	20	13.3	6.7	50	50
800	32	47.4	52.6	32.3	32.3	19.4	16.1	45.5	27.3	27.3	12.5	25	25	18.8	18.8	50	50
801	3	44.4	55.6	29.2	23.4	23.3	24	41.7	33.3	25	15	15	20	25	25	50	50
802	12	44.4	55.6	21.4	21.4	28.6	28.6	40	28	32	15.8	15.8	15.8	26.3	26.3	50	50
803	1	41.2	58.8	24.2	21.2	30.3	24.2	41.7	33.3	25	25.8	32.3	9.7	16.1	16.1	44.4	55.6
804	24	44.4	55.6	29.4	23.5	23.5	23.5	37	33.3	29.6	26.3	26.3	26.3	10.5	10.5	50	50
805	29	44.4	55.6	20.3	16.9	28.8	33.9	37	37	25.9	32.3	19.4	19.4	9.7	19.4	52.6	47.4