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The extinction risk of New Zealand chondrichthyans

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deepwater, marine management

1 **Abstract**

2

3 1. The national extinction risk of New Zealand chondrichthyans (sharks, rays, and chimaeras),
4 which accounts for ~10% of the global chondrichthyan fauna, was evaluated for the first time
5 using the IUCN Red List of Threatened Species Categories and Criteria. Across 32 families, 103
6 species were assessed.

7 2. New Zealand holds a high degree of species endemism (20%) with deepwater species
8 dominating the fauna (77%). Sharks were the most speciose group with 68 species (66%),
9 followed by 24 rays (23%), and 11 chimaeras (10%).

10 3. Most species were assessed as Least Concern (60%, 62 species) or Data Deficient (32%, 33
11 species), with four (3.8%) species listed as Near Threatened, and four (3.8%) in a threatened
12 category (Vulnerable, Endangered, Critically Endangered). Threatened species are all oceanic
13 pelagic, of which two are only visitors to New Zealand waters, and their status the result of
14 broader regional declines.

15 4. These results are in stark contrast to other recent regional assessments in Europe and the
16 Arabian Sea and adjacent areas, where up to half of species were listed in a threatened category.
17 However, given New Zealand's extensive deepwater fishing effort and rapid collapses of
18 deepwater chondrichthyan fisheries elsewhere, it is possible that New Zealand populations of
19 many deepwater species are the remnants of previously reduced populations which are now at a
20 low, yet stable level. Ongoing species-level catch monitoring will be required to ensure these
21 species do not become threatened.

22 5. Recommendations for future research and conservation efforts include resolving taxonomic
23 uncertainties, understanding habitat use, and increasing regional collaborations to better
24 understand the effects of fishing on wider-ranging species.

1. Introduction

Sharks, rays, and chimaeras (Class Chondrichthyes) are under increasing global threat. Their general life history features (e.g. late maturity, slow growth, low fecundity) which result in low biological productivity, as well as demand for shark products in domestic and international markets, increase their susceptibility to overfishing (Daley, Stevens, & Graham, 2002; Dulvy et al., 2014). Population declines have been recorded across a number of regions and species (e.g. Graham, Andrew, & Hodgson, 2001; Jabado et al., 2017), with some species disappearing from areas altogether (e.g. Luiz & Edwards, 2011; Dulvy et al., 2016).

One hundred and twelve chondrichthyan species from 32 families have been reported from New Zealand's Exclusive Economic Zone (EEZ) (Ford et al., 2018). The diversity of cartilaginous fishes (~10% of the global chondrichthyan fauna) includes coastal, pelagic, and deepwater species, some of which are wide-ranging while others are known only from limited distributions within New Zealand. With improved species identification, taxonomic resolution, and further exploration of the marine environment, this diversity continues to increase. New species (e.g. Kemper, Ebert, Naylor, & Didier, 2014), and new species records (e.g. Duffy, Forrester, Gibson, & Hathaway, 2017) are documented regularly.

Commercial fishing is the primary threat to New Zealand chondrichthyans (Ford et al., 2018). While chondrichthyans do not make up large proportions of catches from commercial fisheries, New Zealand does have a long history of shark, ray, and chimaera fisheries (see Francis, 1998). Commercial fisheries for species such as school shark (*Galeorhinus galeus* L., 1758) began as early as the 1900s, but landings are thought to have remained low until demand for flesh and liver oil rose in the 1940s and 1950s (Francis, 1998). Today, chondrichthyans are often not targeted in New Zealand, but bycatch is regularly utilized both locally and internationally (Clarke, Francis, & Griggs, 2013; Francis, 1998). Approximately 80 species are reported in the catches of commercial vessels, with spiny dogfish (*Squalus acanthias* L., 1758) being the most recorded species (~24 000 t recorded between 2008-13, Francis, 2015). In addition, small quantities of chondrichthyans such as rig (*Mustelus lenticulatus* Phillipps, 1932) and elephantfish (*Callorhynchus milii* Bory de Saint-Vincent, 1823) are taken by recreational fishers, while larger species like the shortfin mako (*Isurus oxyrinchus* Rafinesque, 1810) have been popular with big game fishers (Francis, 1998, MPI, 2013). These species, and others, also

56 have customary significance, as chondrichthyans were an important source of food, oil,
57 jewellery, and tools for Maori communities (Francis, 1998).

58 New Zealand chondrichthyans are managed under one of the following categories to
59 ensure sustainable utilization or protection: 11 species are managed under the Quota
60 Management System (QMS), seven species are fully protected, and two species are prohibited as
61 targets under Schedule 4C of the *Fisheries Act 1996* (Table 1). All other species (i.e. most New
62 Zealand chondrichthyans) are open access. These are predominately deepwater species with
63 negligible economic value. There is no species-specific management of these species and little
64 mitigation in place to protect them or to reduce catches (MPI, 2013).

65 In addition to this legislation, New Zealand has implemented several strategies to guide
66 the management and conservation of its chondrichthyan species. These have included the
67 development of its National Plan of Action for sharks (NPOA), first released in 2008, reviewed
68 in 2013, and expected to be reviewed again in 2018 (MPI, 2013). Outlined as an objective for the
69 NPOA, a qualitative (Level 1) risk assessment with a modified Scale Intensity Consequence
70 Analysis (SICA) was conducted in 2014 for all New Zealand chondrichthyans to assess risk from
71 commercial fishing, with the intention to inform management and assist prioritizing action (Ford
72 et al., 2015). This assessment was reviewed and updated for 50 taxa in 2017 (Ford et al., 2018).
73 New Zealand is a member of Regional Fisheries Bodies (RFBs), including the Western and
74 Central Pacific Fisheries Commission (WCPFC), and internationally, is a Party to the
75 Convention on Migratory Species (CMS), signatory of the Memorandum of Understanding on
76 the Conservation of Migratory Sharks (Sharks MOU, also an NPOA objective), and a Party to
77 the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
78 More recently, the conservation status of all known New Zealand chondrichthyan taxa was
79 reassessed using the New Zealand Threat Classification System (NZTCS) (Duffy et al., 2018), a
80 system tailored for New Zealand (Townsend et al., 2008), but which differs considerably from
81 the IUCN Red List of Threatened Species, the world's most utilized extinction risk framework
82 (IUCN, 2012a).

83 The IUCN Red List is the most comprehensive inventory of the global status of animal,
84 plant and fungi species, employing a single standardized set of categories and criteria to evaluate
85 the extinction risk of tens of thousands of species worldwide (Collen et al., 2016; IUCN, 2012a;
86 Mace et al., 2008). The IUCN Species Survival Commission's Shark Specialist Group (SSG) is

87 currently undertaking a global reassessment of all chondrichthyan fishes worldwide (~1 250
88 species), which will provide the first baseline of changes in the global and regional status of
89 chondrichthyans since the original assessments conducted >10 years ago (Dulvy et al., 2014).

90 This paper aims to assess the extinction risk of New Zealand chondrichthyans at the
91 national level. Previous assessments of New Zealand species have been included within broader
92 regional or global reviews (e.g. Cavanagh, Kyne, Fowler, Musick, and Bennett, 2003). By
93 applying the IUCN Red List of Threatened Species Categories and Criteria, the following work
94 presents a comparative view of the extinction risk of New Zealand chondrichthyans relative to
95 other regions where similar regional-level assessments have been undertaken. The completion of
96 a comprehensive national assessment will complement management tools and assist in guiding
97 future conservation and research efforts.

98 **2. Methods**

99

100 A preliminary species list of 112 New Zealand chondrichthyans was compiled using the
101 most recently available knowledge as presented in *Fishes of New Zealand*, a comprehensive
102 review of all New Zealand fishes published by the Museum of New Zealand Te Papa Tongarewa
103 (Roberts, Stewart, & Struthers, 2015). This species list was refined by removing vagrants (a
104 taxon only occasionally found within the boundaries of a region) and species with unresolved
105 taxonomy, including formally undescribed species, to produce a final list of 103 species. Species
106 were assessed as breeding (reproduces within the region, which may involve the entire
107 reproductive cycle or any essential part of it), or visiting (does not reproduce within a region but
108 regularly occurs within its boundaries) populations (IUCN, 2012b). All available information,
109 including published reports (e.g. fisheries-independent research surveys, national fisheries stock
110 assessments, indicator analyses, technical reports), government documents (e.g. National Plan of
111 Action-Sharks, risk assessments), relevant scientific journal publications, and unpublished
112 literature was compiled for each species.

113 A two-day workshop was carried out by five experts and members of the IUCN Species
114 Survival Commission’s Shark Specialist Group (SSG). Each chondrichthyan species was
115 assessed against the IUCN Red List Categories and Criteria (Version 3.1) (IUCN, 2012a; IUCN
116 Standards and Petitions Subcommittee, 2017), together with the Guidelines for Application of
117 IUCN Red List Criteria at Regional and National Levels (Version 4.0) (IUCN, 2012b). The
118 regional guidelines can be applied at “any sub-global geographically-defined area, such as a
119 continent, country, state, or province” (IUCN, 2012b). In this study, guidelines were applied at
120 the national level, and assessments were undertaken using population sizes and trends, threats,
121 and extinction risk only within the New Zealand EEZ. For New Zealand endemic species, the
122 national assessment by default became the global assessment (since the species is found nowhere
123 else), and as such these Red List assessments were submitted to IUCN for publication on the Red
124 List of Threatened Species (<http://www.iucnredlist.org/>). For those species assessed as visiting,
125 the current status of the source population was evaluated, and the species’ New Zealand status
126 was assessed to be consistent with that of regional populations.

127 Each species was assessed against each of five quantitative criteria, referred to as criteria
128 A-E: Criterion A, population size reduction; B, geographic range; C, small population size and

129 decline; D, very small or restricted population; and E, quantitative analysis (for example, a
130 population viability analysis indicating a probability of extinction; these are not available for any
131 New Zealand chondrichthyan). Species were assigned to one of the following IUCN Red List
132 categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered
133 (EN), Vulnerable (VU), (collectively, CR, EN, and VU are the ‘threatened’ categories), Near
134 Threatened (NT), Least Concern (LC), or Data Deficient (DD) (for definitions, see IUCN,
135 2012a). The DD category is applied to taxa where there is inadequate information available to
136 make an assessment of extinction risk (IUCN, 2012a). If a species qualified for a change in status
137 from a previously published assessment (a ‘down-listing’ or ‘up-listing’ in status), changes were
138 classified as genuine (a change in its extinction risk), or non-genuine (due to new information, or
139 an error in the previous assessment) (IUCN Standards and Petitions Subcommittee, 2017).
140 Following the regional IUCN guidelines, an evidentiary attitude was considered, and a species
141 was listed as threatened only when evidence to support a threatened classification was presented.
142 See IUCN (2012a) and IUCN Standards and Petitions Subcommittee (2017) for explanations and
143 guidelines of use.

144 To evaluate the diversity and degree of threat across chondrichthyan groups, species were
145 divided into subgroups based on their geographic occurrence [New Zealand endemic, Australasia
146 (New Zealand, Australia, and neighbouring Pacific nations), wider Pacific Ocean, global (wide-
147 ranging across multiple ocean basins)], and major habitat and depth associations [coastal:
148 primary distribution from the shore to 12 nautical miles, nm (New Zealand’s Territorial Sea);
149 pelagic: primary distribution beyond 12 nm and at depths <200 m; deepwater: primary
150 distribution at depths >200 m). Geographic occurrence and habitat association data were largely
151 compiled from Last and Stevens (2009), Roberts et al. (2015), and Last et al. (2016). The New
152 Zealand regional assessment was compared with regional chondrichthyan extinction risk
153 assessments, which have been conducted recently for Europe (Nieto et al., 2015) and the Arabian
154 Sea and adjacent areas (hereinafter referred to as Arabian Sea, Jabado et al., 2017).

3. Results

Species Diversity and Endemism

A total of 103 species across 32 families were considered for assessment (Table 2). Sharks were the most speciose group with 68 species from 22 families (66%), followed by 24 rays from seven families (23%), and 11 chimaeras from three families (10%). Twenty percent of species were endemic to New Zealand waters, with rays and chimaeras having high levels of endemism at 38% and 36%, respectively, while shark endemism was 12%. Half of the species assessed from New Zealand are globally distributed, 17% are restricted to Australasia, and 12% to the greater Pacific region. Most chimaeras (>70%) were restricted to New Zealand or Australasian waters, while most sharks (64%) were distributed globally. The majority of species (77%) were classified as deepwater, with chimaeras having the highest proportion of deepwater species (91%). Across all chondrichthyans, 17% and 8% of species were classified as pelagic and coastal, respectively (Table 2).

Extinction risk

Most species were assessed as either Least Concern (60%, 62 species) or Data Deficient (32%, 33 species) with four (3.8%) listed as Near Threatened, two (1.9%) as Vulnerable, and one each as Endangered (<1%) and Critically Endangered (<1%) (Table 3). Across groups, chimaeras were primarily LC (91%, 10 species) with one DD species, leopard chimaera (*Chimaera panthera* Didier, 1998). Rays were equally assessed as LC or DD, and sharks were mostly LC (56%), followed by DD (32%), NT (6%), VU (3%), EN (1.5%), and CR (1.5%) (Figure 2). Twelve families were found to have high levels of data deficiency (>30% of species within the family assessed as DD). Arhynchobatidae and Somniosidae were the most speciose families with high levels of data deficiency, with 77% and 50%, respectively (Table 4).

Threatened breeding species

Two species (1.9%) were listed as VU: white shark (*Carcharodon carcharias* L., 1758,) and basking shark (*Cetorhinus maximus* (Gunnerus, 1765)). Both species are now protected in New Zealand, but are still caught incidentally in trawl and set net fisheries (Francis & Lyon, 2012a, Francis, 2017a, Francis, 2017b). The total population of white sharks on the east coast of

186 Australia and New Zealand was recently estimated to be 5460 individuals, including 750 mature
187 individuals (Bruce et al., 2018), suggesting the population within New Zealand waters alone met
188 Criterion D ('very small or restricted population', <1000 mature individuals). Given their
189 naturally low population size, combined with a low estimate of maximum intrinsic rate of
190 population increase (r_{max}) (Pardo, Kindsvater, Reynolds, & Dulvy, 2016), and documented
191 interactions with fishers, some continuing population decline is projected (10% over three
192 generations; generation length = 39 years based on age data from Natanson and Skomal, 2015),
193 the white shark also met Criterion C ('small population size and decline').

194 Basking shark met the criteria for VU under Criterion A ('population reduction measured
195 over the longer of 10 years or three generations') and Criterion C. Observed raw catch per unit
196 effort (CPUE) by trawlers showed that peak abundance of basking shark occurred in 1988-91,
197 corresponding with Japanese vessels catching relatively large numbers (>50) in some years
198 (Francis & Sutton, 2012). It is unknown if basking shark was targeted for liver oil and fins, or if
199 there was a high abundance of sharks during this period, however, catch has been near or at zero
200 since the mid-2000s, which may reflect a change in fishing gear, regional availability of sharks,
201 or a true decline in abundance (Francis, 2017b). A total of 922 individuals were estimated to
202 have been taken as commercial bycatch from 1994-95 to 2007-08, although this estimate does
203 not include captures in unobserved set net and inshore trawl fisheries (Francis & Smith, 2010).
204 This level of catch is comparable to that which took place from 1945 to 1970 off the coast of
205 British Columbia, Canada, where an estimated minimum population size of 750 was reduced to a
206 near local extinction (COSEWIC, 2007). Population trend therefore met Criterion A, that is, a
207 suspected population decline of >30% over the past three generations [generation length
208 estimated as 34 years, Pauly (1978) and Compagno (1984)], due to 'actual levels of
209 exploitation'. Furthermore, population size within New Zealand is likely to be <10 000 mature
210 individuals, with a projected continuing decline over three generations (Criterion C) based upon
211 estimates of global population size and trend (e.g. Westgate, Koopman, Siders, Wong, &
212 Ronconi, 2014).

213

214 *Near Threatened breeding species*

215 Two species (1.9%) were listed as NT. Plunket shark (*Scymnodon plunketi* (Waite,
216 1910)) and prickly dogfish (*Oxynotus bruniensis* (Ogilby, 1893)) were close to meeting the

217 criteria for the threatened categories, and were thus listed as NT. Both species have life histories
218 suggestive of low productivity (Finucci, Bustamante, Jones, & Dunn, 2016; Francis, Jones, Ó
219 Maolagáin, & Lyon, 2018), as well as high distribution overlap with fishing across much of their
220 range (45-60% and > 60% overlap, respectively) (Ford et al., 2015, 2018). While research trawl
221 survey relative biomass showed no trends in the Fisheries Management Areas (FMAs) where
222 plunket shark and prickly dogfish have been caught, monitoring of the species is poor
223 (coefficient of variation, CV, of biomass estimates >40% or greater), and, at least in the case of
224 plunket shark, reasons for a lack of trends is unknown (Francis, Roberts, & MacGibbon, 2016).
225 With estimated generation lengths of 20 (prickly dogfish) and 34 (plunket shark) years, it is
226 suspected that a population decline has occurred over three generations for both species given
227 fisheries overlap, but not at a level (30%) that would qualify for a threatened category.

228

229 *Change in status*

230 One species, smooth skate (*Dipturus innominatus* (Garrick & Paul, 1974)), was down-
231 listed from NT in 2003 to LC in 2017. Implemented management efforts and indications that
232 declines in population have ceased since its previous assessment suggested smooth skate no
233 longer met NT due to a genuine change in status and was thus assessed as LC.

234

235 *Visiting species*

236 Five species were considered visitors to New Zealand: oceanic whitetip (*Carcharhinus*
237 *longimanus* (Poey, 1861)), dusky shark (*Carcharhinus obscurus* (Lesueur, 1818)), tiger shark
238 (*Galeocerdo cuvier* (Péron & Lesueur, 1822)), giant devilray (*Mobula mobular* (Bonnaterre,
239 1788)), and whale shark (*Rhincodon typus* Smith, 1828). While each species is infrequently
240 observed in New Zealand waters (e.g. 19 records of oceanic whitetip between 1996 and 2011,
241 Francis & Lyon, 2014), the source populations for these species from the wider Indo-Pacific
242 have undergone declines, which for some species have been considerable (>90%, Young et al.,
243 2016). These declines are expected to affect the number of individuals that visit New Zealand
244 waters over time. Thus, to be consistent with the current status of regional populations, these
245 visiting species met the following criteria: Oceanic whitetip listed as CR, with a population
246 reduction of >80% over three generations based on data presented in Young et al. (2016). Dusky
247 shark is globally VU, but the source population for New Zealand is Australia, which is regionally

248 NT (close to meeting VU A1bd) on account of additional fisheries management measures
249 implemented in 2006 (Musick, Grubbs, Baum, & Cortés, 2009); dusky shark was thus listed as
250 NT. Tiger shark was listed as NT (close to meeting criterion A2 for VU) (Simpfendorfer, 2009),
251 and whale shark as EN (past and future population reduction of >50% over three generations)
252 based on the assessment for the source population in the Indo-Pacific (Pierce & Norman, 2016).
253 Some declines in catch of *Mobula* spp. have been reported in fisheries managed under the
254 Western and Central Pacific Fisheries Commission (Tremblay-Boyer & Brouwer, 2016), but it is
255 not possible to determine species-specific trends in abundance since species are listed under an
256 aggregate code. Therefore, giant devilray was listed as DD at this time as the effects of fishing
257 on the species within New Zealand and in regional waters are unknown. In addition, there is
258 some evidence to suggest that the species may in fact breed within New Zealand (Duffy and
259 Tindale, 2018).

260

261 *Regional comparison*

262 When compared regionally, endemism in New Zealand (20%) was higher than in Europe
263 (15.2%; Nieto et al., 2015) and comparable to that of the Arabian Sea region (19.6%; Jabado et
264 al., 2017). New Zealand had a much lower proportion of threatened species (4%) than Europe
265 (32%; Nieto et al., 2015) and the Arabian Sea region (51%; Jabado et al., 2017). New Zealand
266 had the highest proportion of both DD and LC species, but unlike the other regions, had no
267 breeding species listed as EN or CR (Table 5). Forty-two species assessed in New Zealand were
268 also assessed in Europe or the Arabian Sea, 17 of which were assessed across all three regions.
269 Only one species, pelagic stingray (*Pteroplatytrygon violacea* (Bonaparte, 1832)) was assessed
270 as LC across all three regions. No species had a higher threat assessment in New Zealand than
271 Europe or the Arabian Sea. For some species, the extinction risk was much greater in the other
272 regions [e.g. leafscale gulper shark (*Centrophorus squamosus* (Bonnaterre, 1788)), LC in New
273 Zealand; EN in other regions] (Fig. 3, Appendix I).

274 **4. Discussion**

275

276 New Zealand waters contain ~10% of the global chondrichthyan diversity, with a low
277 overall risk of extinction. Many species are endemic to the region (20%), and New Zealand also
278 hosts a substantial proportion of the recognized chimaeroid diversity (~20%). The low extinction
279 risk of the region (4%) is a stark contrast to other recent regional assessments, where a third and
280 over half of species in Europe and the Arabian Sea were listed in a threatened category,
281 respectively (Jabado et al., 2017; Nieto et al., 2015). Where chondrichthyans were found across
282 regions, species were listed at much higher risk of extinction outside New Zealand, particularly
283 those that are deepwater. These contrasting scenarios between New Zealand and two other
284 regions may result from New Zealand having some of the better studied and managed
285 chondrichthyan fisheries in the world, and continued effective regional management may be
286 critical for globally threatened and near-threatened species. Alternatively, historical declines in
287 these species in New Zealand may have gone undocumented, and if so, population recovery
288 would be expected to be slow, as many species are presumed to have low productivity.

289

290 *New Zealand chondrichthyan management under the QMS*

291 On a global scale, several New Zealand Quota Management System (QMS)
292 chondrichthyans, including elephantfish, pale ghost shark (*Hydrolagus bemisi* Didier, 2002), and
293 school shark, have been recognized as some of the more sustainable and well managed shark
294 fisheries (Simpfendorfer & Dulvy, 2017). Sustainable management actions have been reflected
295 in these species' extinction risk. School shark, for example, was assessed as LC in New Zealand,
296 where relative CPUE biomass indices have been increasing or remained stable (between 1990/91
297 to 2013/14 fishing seasons) (MPI, 2017). Globally, the species is listed as VU, with considerable
298 suspected population decline in part of its range due to intensive fishing and habitat degradation
299 (Walker et al., 2006). In neighbouring Australia, school shark is listed as Conservation
300 Dependent, and targeted fishing in the Southern and Eastern Scalefish and Shark Fishery
301 (SESSF) is prohibited (AFMA, 2013). Available data suggest other species, such as blue shark
302 (*Prionace glauca* (L., 1758)) and shortfin mako, are increasing in abundance in New Zealand
303 (Francis, Clarke, Griggs, & Hoyle, 2014), and were listed nationally as LC. Elsewhere, these
304 species have been assessed to have a much higher extinction risk (e.g. both are listed as CR in

305 the Mediterranean, Walls & Soldo, 2016). In the North Atlantic, the mako is considered
306 overfished (Sims, Mucientes, & Queiroz, 2018).

307 The implementation of species-specific management in New Zealand has been shown to
308 improve species status. For example, smooth skate, originally assessed as NT in 2003, was
309 down-listed to LC as a result of active management. While not targeted, this species has been,
310 and continues to be commonly caught as bycatch by benthic trawlers and longliners throughout
311 New Zealand waters (MPI, 2017). In 2002, it was highlighted that a combination of fishing
312 activities, small latitudinal range and limited depth refuge, as well as life history traits (large
313 body size; longevity >24 years; late age at maturity, 13 years for females) may threaten this
314 species (Dulvy & Reynolds, 2002). Smooth skate catches were regularly lumped together with
315 the similar looking rough skate (*Zearaja nasuta* (Müller & Henle, 1941)), making it impossible
316 to accurately quantify catches to the species level. In addition, landings for smooth skate had
317 exceeded quota every year since the introduction of quotas in the 1991-1992 fishing season off
318 the east coast of South Island, where most catches were recorded (Francis, 2003). Without
319 management measures to adequately regulate fishing mortality at a sustainable level, declines
320 were expected to continue, and the smooth skate was listed as NT (Francis, 2003).

321 In the same year that it was assessed, the smooth skate was introduced into the QMS,
322 along with the rough skate. The 2003 assessment of the species suggested a review of the
323 species' status after its QMS introduction was operational and CPUE data indicated a stable
324 population. Since then, more sustainable catch limits were set, identification of skate catch
325 improved and lumped recording of the two species reduced, and live release of smooth skate
326 catch has been encouraged with its inclusion under Schedule 6 of the *Fisheries Act 1996* (MPI,
327 2017, Table 1). Relative biomass estimates of smooth skate have increased with each fisheries-
328 independent survey, with the 2015 estimate the highest in the time series (MPI, 2017). New
329 Zealand's inclusion of chondrichthyans within the QMS with annually reviewed catch limits can
330 be viewed as a successful example of sustainable shark management. Catches of all QMS
331 chondrichthyans are currently at levels not considered to be overfished (MPI, 2017). These
332 efforts, however, cover only a small fraction of New Zealand's chondrichthyan species.

333

334 *The need for improved deepwater species monitoring*

335 Most New Zealand chondrichthyans (~80%) have no species-specific management or
336 monitoring. These are predominately deepwater species and are reported as bycatch in
337 commercial fisheries (Francis, 2015). At this time, these species were largely assessed as LC as
338 there was no available information to suggest any population decline or increased extinction risk.
339 Notwithstanding their sensitive life histories (Simpfendorfer & Kyne, 2009), deepwater species
340 are generally less threatened than their shallow water relatives because their distributions extend
341 beyond the depth range of most fishing effort (Dulvy et al., 2014). Without sufficient
342 management and monitoring, however, deepwater chondrichthyan populations can rapidly
343 decline from exploitation. Targeted fishing and incidental bycatch have depleted deepwater
344 chondrichthyan populations in places such as Australia (Graham et al., 2001) and the North
345 Atlantic (ICES, 2009), resulting in management arrangements such as the implementation of
346 zero catch limits (Villasante et al., 2012), and scientific recommendations to cease fishing
347 beyond 600 m (Clarke, Milligan, Bailey, & Neat, 2015).

348 In the absence of species-specific information, there is uncertainty about whether, and to
349 what degree, changes in the abundance of New Zealand chondrichthyan species have occurred
350 over time. Catch histories, which may indicate change in abundance over time when scaled with
351 fishing effort, are difficult, if not impossible, to construct for deepwater chondrichthyan bycatch
352 species in New Zealand. When recorded, catches were often aggregated under a generic code,
353 such as “deepwater dogfish” or “other sharks and dogfish” (Parker & Francis, 2012). While
354 species identification has improved over time (Francis & Lyon, 2012b), fisheries-independent
355 research trawl surveys, which assess the status of commercially valuable species on Chatham
356 Rise and the Campbell Plateau (Bagley, Ballara, O’Driscoll, Fu, & Lyon, 2013; O’Driscoll,
357 MacGibbon, Fu, Lyon, & Stevens, 2011), are the only sources of data for most deepwater
358 chondrichthyans in New Zealand. Abundance indices from these data suggest there have been
359 few trends (no change) in relative biomass for some species since the early 1990s, however,
360 monitoring for most species is poor (Ford et al., 2018; Francis et al., 2016).

361 It is possible that the abundance indices observed today in New Zealand reflect
362 previously depleted populations which are now at a low, yet stable level. Deepwater fisheries in
363 New Zealand emerged in the late 1970s, and over time, these fisheries have dominated global
364 catches of some commercial species found on the continental slope and seamounts, such as hoki
365 (*Macruronus novaezelandiae* (Hector, 1871)) and orange roughy (*Hoplostethus atlanticus*

366 Collett, 1889), with current total allowable commercial catches (TACCs) of 150 000 t and 9800
367 t, respectively (Clarke, 2009, MPI, 2017). At least 77 chondrichthyans are reported as bycatch
368 from commercial fisheries (Anderson, 2017; Francis, 2015). Considerable declines of some
369 bycatch species associated with these deepwater fisheries has been observed. For example, over
370 a ten year period, biomass of plunket shark on north-east Chatham Rise was reported to have
371 declined in 1994 to 6% of that in the previous decade (Clark, Anderson, Francis, & Tracey,
372 2000). It is unknown how representative this area is of the entire range of plunket shark in New
373 Zealand, however, for many deepwater species there is high spatial overlap of fishing in New
374 Zealand waters (Black & Tilney, 2015; Ford et al., 2018). Eighty-five percent of trawled fishing
375 effort in New Zealand occurs at depths <800 m (Black & Tilney, 2015), overlapping with peak
376 depth distributions (Anderson et al., 1998). On Chatham Rise, New Zealand's most productive
377 fishing ground, hoki and orange roughy stocks are considered sustainable, currently managed at
378 targets of 35-50% and 30-40% of unexploited biomass, respectively (MPI, 2017). These targets
379 may be considered desirable to achieve maximum commercial yield, however, declines of this
380 nature for deepwater chondrichthyan species with low productivity and no species-specific
381 management measures could meet the criteria for threatened categories.

382 With their generally low productivity, deepwater species are less likely to recover from
383 exploitation, and it may take decades to observe any signs of recovery towards unexploited
384 biomass levels, particularly with limited monitoring (Simpfendorfer & Kyne, 2009). Species
385 such as leafscale gulper shark and seal shark (*Dalatias licha* (Bonnaterre, 1788)), which are
386 regularly caught in New Zealand, have been assessed as EN in other regions on account of
387 documented declines and limited recovery (Nieto et al., 2015; Jabado et al., 2017). While this is
388 a cause for concern, under current fishing effort and management arrangements in New Zealand,
389 as well as a lack of new information since the completion of previous assessments to suggest
390 declines in populations, these species were listed as LC. This does, however, come with the
391 caveat that ongoing species-level catch monitoring is required to ensure they do not become
392 threatened.

393

394 *Knowledge gaps and future efforts*

395

396 *Taxonomic resolution for improved fisheries reporting*

397 For many species, regardless of their assessment, there was a lack of species-specific
398 data. Of those species listed as DD, nearly all (91%) were deepwater and included many skate
399 species. There is a need for improved taxonomic resolution of morphologically conservative
400 species (e.g. *Brochiraja* spp.) as concerns were raised over the accuracy of catch records and
401 there was uncertainty in assessing the degree of threat for these species. Additional species (e.g.
402 members of the catshark genus *Apristurus*) could not be assessed at this time because of
403 taxonomic uncertainty and the use of generic codes in fishery reporting. Some of these species
404 were previously identified as having a high risk from fishing by Ford et al. (2015), with little
405 knowledge of life histories, habitat use, movement and connectivity, and population size or
406 structure. Despite having consistent, and sometimes, considerable catch records for some of
407 these species, it is difficult to assess how fishing pressures are truly affecting these populations.

408

409 *Understanding habitat use and conserving habitats of importance*

410 Identification and protection of habitats of importance should be investigated and
411 implemented to conserve the diversity of New Zealand's chondrichthyans. Spatial use of the
412 water column or depth preference of different life history stages, which may increase
413 vulnerability to fishing mortality from multiple types of fishing gear (Speed, Field, Meekan, &
414 Bradshaw, 2010), is also not well known, and thus, cannot be taken into account for assessments.
415 Without an understanding of habitat use, it is difficult to assess if these areas provide any refuge
416 for most New Zealand chondrichthyans.

417 New Zealand has a series of Benthic Protected Areas (BPAs), seamount closures, and
418 marine reserve areas within its EEZ designed to manage and protect the marine environment
419 (Cryer, Mace, & Sullivan, 2016). BPAs, which protect seabed habitats through the prohibition of
420 benthic trawling and dredging, are unlikely to provide any major refuge for most
421 chondrichthyans given the distribution of species and spatial occurrence of the BPAs themselves
422 (see Black & Tilney, 2015). New industries, such as deepwater mining, should also be closely
423 monitored as they will most likely impact the New Zealand deepwater environment and benthic-
424 associated species (Leduc, Rowden, Torres, Nodder, & Pallentin, 2015). The current known
425 range of one species, the Kermadec Spiny Dogfish (*Squalus raoulensis* Duffy & Last, 2007), lies
426 exclusively within the Kermadec Islands Marine Reserve, where fishing and mining is currently
427 prohibited. The species may also occur beyond the reserve on nearby unexplored habitat located

428 within a designated BPA. Of all chondrichthyans, it is the only species with its known range
429 entirely within a marine protected area (Davidson & Dulvy, 2017). Virtually nothing is known
430 about the biology of this species, however, many *Squalus* spp. are known for their low biological
431 productivity (Graham et al., 2001). Although unlikely under the current political environment,
432 opening this area to exploitative activities may result in rapid depletion of the species.

433

434 *Increased collaborations*

435 With limited budgets for fisheries research, priority is given to monitoring and assessing
436 high value fish stocks, while species with little or no commercial value, such as many
437 chondrichthyans, receive little, if any, research attention (Mace, Sullivan, & Cryer, 2014). As
438 research surveys are generally the only means of data collection for many species, the collection
439 of detailed life history information beyond the usual standard length, mass, and sex
440 measurements (O'Driscoll et al., 2011), are needed to adequately describe species knowledge
441 gaps. Increased collaboration with the fishing industry and the government-sponsored observer
442 program is encouraged, as it can also allow for greater sampling coverage beyond the spatial and
443 temporal range of research surveys.

444 As some species migrate beyond New Zealand waters, including species with heightened
445 threat statuses regionally and globally, continued collaboration with neighbouring nations is
446 crucial, particularly for those species susceptible to capture in wider Pacific fisheries. For
447 example, tagging studies have indicated that giant devilray migrate seasonally between New
448 Zealand and northern subtropical or tropical areas (Francis & Jones, 2017). Catches of mobulids
449 are high outside New Zealand, however, species reporting is aggregated (Tremblay-Boyer &
450 Brouwer, 2016), limiting population monitoring. While there is little to suggest there have been
451 changes in catch rates of giant devilray within New Zealand waters, the impact of fishing outside
452 the New Zealand EEZ, and how that may affect the New Zealand visiting population, is
453 unknown (Francis & Jones, 2017). Species such as oceanic whitetip and whale shark, now listed
454 as CR and EN, respectively, have undergone considerable population declines in the Indo-West
455 Pacific due to intensive fishing pressure (Pierce & Norman, 2016; Young et al. 2016). These
456 species are considered low research priority for New Zealand given infrequent recordings (e.g.
457 Francis & Lyon, 2014), but any continued deterioration of their population outside New Zealand
458 waters will likely affect the number of visiting individuals observed within New Zealand.

459 Ongoing collaborative projects across the South Pacific are underway to assess species' mortality
460 of shortfin mako and silky shark (*Carcharhinus falciformis* (Müller & Henle, 1839)) in pelagic
461 longline fisheries (Western and Central Pacific Fisheries Commission unpub. data), and such
462 efforts could extend to other species in the future.

463

464 The national risk of extinction for New Zealand chondrichthyans has been assessed, and
465 overall, it is concluded that there is a low proportion of threatened species. When compared to
466 other assessed regions, the low risk of extinction suggests that New Zealand chondrichthyans are
467 generally well managed. However, there is a lack of species-specific data and species-specific
468 management for most species, which can impede assessing the degree of threat, past or present,
469 with certainty. Increased monitoring is highly recommended to improve knowledge and ensure
470 changes in species status, resulting from management measures or resolution in species
471 identification, can be accurately assessed.

472

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474

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708 **FIGURE LEGENDS**

709

710 Figure 1. Map of New Zealand showing the boundary of its Exclusive Economic Zone (EEZ),
711 North Island (NI), South Island (SI) and Kermadec Ridge, major plateaus, and the 1000 m
712 isobath (grey line).

713

714 Figure 2. By species group, proportion of New Zealand chondrichthyans in each of the IUCN
715 Red List of Threatened Species categories.

716

717 Figure 3. Of the New Zealand species ($n = 42$) which have also been assessed in the Arabian Sea
718 ($n = 20$), and Europe ($n = 39$), the proportion of species assessed each of the IUCN Red List of
719 Threatened Species categories by region (DD, Data Deficient; LC, Least Concern; NT, Near
720 Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered).

721 Table 1. Management categories for chondrichthyans in New Zealand (MPI, 2013).

Management Category	Quota Management System (QMS) Fisheries Act 1996	Protected Schedule 7A Wildlife Act 1953	Schedule 4C Fisheries Act 1996	Open Access Fisheries Act 1996
Management action	Individual transferable quotas (ITQs)	No utilization permitted	No target fishing; may only be taken as bycatch	No species-specific measures
Species	Elephantfish (<i>Callorhynchus milii</i> Bory de St Vincent, 1823)	Oceanic whitetip (<i>Carcharhinus longimanus</i> (Poey, 1861))†	Sharpnose sevengill shark (<i>Heptranchias perlo</i> (Bonnaterre, 1788))	All other species
	Smooth skate (<i>Dipturus innominatus</i> (Garrick & Paul, 1974))‡	White shark (<i>Carcharodon carcharias</i> (L., 1758))†	Smooth hammerhead (<i>Sphyrna zygaena</i> (L., 1758))	
	School shark (<i>Galeorhinus galeus</i> (L., 1758))‡	Basking shark (<i>Cetorhinus maximus</i> (Gunnerus, 1765))†		
	Pale ghost shark (<i>Hydrolagus bemisi</i> Didier, 2002)	Giant manta ray (<i>Mobula birostris</i> (Walbaum, 1792))		
	Dark ghost shark (<i>Hydrolagus novaezealandiae</i> (Fowler, 1911))	Spinetail devilray (<i>Mobula japonica</i> (Müller & Henle, 1841))§		
	Shortfin mako (<i>Isurus oxyrinchus</i> Rafinesque, 1810)‡	Smalltooth sand tiger (<i>Odontaspis ferox</i> (Risso, 1810))		
	Porbeagle	Whale shark		

	(<i>Lamna nasus</i> (Bonnaterre, 1788))‡	(<i>Rhincodon typus</i> Smith, 1828)		
	Rig (<i>Mustelus lenticulatus</i> Phillipps, 1932)‡			
	Blue shark (<i>Prionace glauca</i> (L., 1758))‡			
	Spiny dogfish (<i>Squalus acanthias</i> L., 1758)‡			
	Rough skate (<i>Zearaja nasuta</i> (Müller & Henle, 1841))‡			
†Species also protected under the Fisheries Act 1996 ‡ Species also included in Schedule 6 of the Fisheries Act 1996 where catch can be returned alive if the individual is likely to survive and the return takes place as soon as possible (blue shark, porbeagle, mako, and spiny dogfish can be returned dead or alive) § <i>Mobula japonica</i> is a junior synonym of <i>Mobula mobular</i> (Bonnaterre, 1788) (White et al., 2018)				

723 Table 2. The number of New Zealand chondrichthyans assessed against the IUCN Red List of
 724 Threatened Species Categories and Criteria by major taxonomic group, and the proportion of
 725 each group by major geographic occurrence and habitat association.

726

Group	n families	n species	Geographic Occurrence				Habitat Association		
			Endemic	Australasia	Greater Pacific	Global	Coastal	Pelagic	Deepwater
Sharks	22	68	0.120	0.100	0.150	0.630	0.060	0.200	0.740
Rays	7	24	0.380	0.290	0.040	0.290	0.125	0.125	0.750
Chimaeras	3	11	0.365	0.365	0.090	0.180	0.090	0.000	0.910
All Chondrichthyans	32	103	0.200	0.180	0.120	0.500	0.080	0.160	0.760

727

728 Table 3. National extinction risk of all New Zealand chondrichthyans (in alphabetical order by
729 family, genus and species) assessed against the IUCN Red List of Threatened Species Categories
730 and Criteria. IUCN Red List of Threatened Species categories: DD, Data Deficient; LC, Least
731 Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered.
732 See IUCN (2012a) for explanations of Categories and Criteria.
733

Family	Species name	Common name	National Red List Assessment
Alopiidae	<i>Alopias superciliosus</i>	Bigeye thresher	LC
	<i>Alopias vulpinus</i>	Thresher shark	DD
Arhynchobatidae	<i>Arhynchobatis asperrimus</i>	Longtail skate†	LC
	<i>Bathyraja pacifica</i>	Pacific blonde skate†	LC
	<i>Bathyraja richardsoni</i>	Richardson's skate	LC
	<i>Bathyraja shuntovi</i>	Longnose deepsea skate†	DD
	<i>Brochiraja albilabiata</i>	Whitemouth skate†	DD
	<i>Brochiraja asperula</i>	Smooth deepsea skate†	DD
	<i>Brochiraja heuresa</i>	Eureka skate	DD
	<i>Brochiraja leviveneta</i>	Blue deepsea skate	DD
	<i>Brochiraja microspinifera</i>	Dwarf skate†	DD
	<i>Brochiraja spinifera</i>	Prickly deepsea skate	DD
	<i>Brochiraja vittacauda</i>	Ribbontail skate	DD
	<i>Notoraja alisae</i>	Velcro skate	LC
<i>Notoraja sapphira</i>	Sapphire skate	DD	
Callorhynchidae	<i>Callorhynchus milii</i>	Elephantfish	LC
Carcharhinidae	<i>Carcharhinus brachyurus</i>	Bronze whaler	LC
	<i>Carcharhinus galapagensis</i>	Galapagos shark	LC
	<i>Carcharhinus longimanus</i>	Oceanic whitetip shark‡	CR A2bd
	<i>Carcharhinus obscurus</i>	Dusky shark‡	NT
	<i>Carcharhinus plumbeus</i>	Sandbar shark	DD
	<i>Galeocerdo cuvier</i>	Tiger shark‡	NT
	<i>Prionace glauca</i>	Blue shark	LC

Centrophoridae	<i>Centrophorus harrissoni</i>	Harrisson's dogfish	DD
	<i>Centrophorus squamosus</i>	Leafscale gulper shark	LC
	<i>Deania calcea</i>	Shovelnose dogfish	LC
	<i>Deania hystricosa</i>	Rough shovelnose dogfish	DD
	<i>Deania quadrispinosum</i>	Longsnout dogfish	DD
Cetorhinidae	<i>Cetorhinus maximus</i>	Basking shark	VU A2d; C1
Chimaeridae	<i>Chimaera carophila</i>	Brown chimaera†	LC
	<i>Chimaera lignaria</i>	Giant purple chimaera	LC
	<i>Chimaera panthera</i>	Leopard chimaera†	DD
	<i>Hydrolagus bemisi</i>	Pale ghost shark†	LC
	<i>Hydrolagus homonycteris</i>	Black ghost shark	LC
	<i>Hydrolagus novaezelandiae</i>	Dark ghost shark†	LC
	<i>Hydrolagus trolli</i>	Pointynose blue ghost shark	LC
Chlamydoselachidae	<i>Chlamydoselachus anguineus</i>	Frilled shark	LC
Dalatiidae	<i>Dalatias licha</i>	Seal shark	LC
	<i>Euprotomicrus bispinatus</i>	Pygmy shark	LC
	<i>Isistius brasiliensis</i>	Cookiecutter shark	LC
Dasyatidae	<i>Bathytoshia breviceaudata</i>	Shorttail stingray	LC
	<i>Bathytoshia lata</i>	Longtail stingray	LC
	<i>Pteroplatytrygon violacea</i>	Pelagic stingray	LC
Echinorhinidae	<i>Echinorhinus brucus</i>	Bramble shark	DD
	<i>Echinorhinus cookei</i>	Prickly shark	DD
Etmopteridae	<i>Centroscyllium kamoharai</i>	Bareskin dogfish	DD
	<i>Etmopterus granulosus</i>	Baxter's dogfish	LC
	<i>Etmopterus lucifer</i>	Lucifer dogfish	LC
	<i>Etmopterus molleri</i>	Moller's lanternshark	LC
	<i>Etmopterus pusillus</i>	Smooth lanternshark	LC
	<i>Etmopterus unicolor</i>	Shortspine lanternshark	LC
	<i>Etmopterus viator</i>	Traveler lanternshark	LC
Hexanchidae	<i>Heptranchias perlo</i>	Sharpnose sevengill shark	DD
	<i>Hexanchus griseus</i>	Bluntnose sixgill shark	DD
	<i>Notorynchus cepedianus</i>	Broadnose sevengill shark	LC

Lamnidae	<i>Carcharodon carcharias</i>	White shark	VU C1+2(i,ii); D1
	<i>Isurus oxyrinchus</i>	Shortfin mako	LC
	<i>Lamna nasus</i>	Porbeagle	LC
Mitsukurinidae	<i>Mitsukurina owstoni</i>	Goblin shark	DD
Mobulidae	<i>Mobula birostris</i>	Giant manta ray	LC
	<i>Mobula mobular</i>	Giant devilray‡	DD
Myliobatidae	<i>Myliobatis tenuicaudatus</i>	New Zealand eagle ray	LC
Narkidae	<i>Typhlonarke aysoni</i>	Blind electric ray†	LC
Odontaspidae	<i>Odontaspis ferox</i>	Smalltooth sand tiger	LC
Oxynotidae	<i>Oxynotus bruniensis</i>	Prickly dogfish	NT
Pentanchidae	<i>Apristurus albisoma</i>	Grey roundfin catshark	DD
	<i>Apristurus ampliceps</i>	Roundfin catshark	LC
	<i>Apristurus exsanguis</i>	New Zealand catshark†	LC
	<i>Apristurus garricki</i>	Garrick's catshark†	LC
	<i>Apristurus melanoasper</i>	Fleshynose catshark	DD
	<i>Apristurus pinguis</i>	Bulldog catshark	LC
	<i>Apristurus sinensis</i>	Freckled catshark	LC
	<i>Parmaturus macmillani</i>	McMillan's catshark†	DD
Pseudocarchariidae	<i>Pseudocarcharias kamoharai</i>	Crocodile shark	DD
Pseudotriakidae	<i>Gollum attenuatus</i>	Slender smoothhound	LC
	<i>Pseudotriakis microdon</i>	False catshark	DD
Rajidae	<i>Amblyraja hyperborea</i>	Thorny skate	LC
	<i>Dipturus innominatus</i>	Smooth skate†	LC
	<i>Zearaja nasuta</i>	Rough skate†	LC
Rhincodontidae	<i>Rhincodon typus</i>	Whale shark‡	EN A2bd+4bd
Rhinochimaeridae	<i>Harriotta haeckeli</i>	Smallspine spookfish	LC
	<i>Harriotta raleighana</i>	Longnose spookfish	LC
	<i>Rhinochimaera pacifica</i>	Pacific spookfish	LC
Scyliorhinidae	<i>Bythaelurus dawsoni</i>	Dawson's catshark†	LC
	<i>Cephaloscyllium isabellum</i>	Carpet shark†	LC
Somniosidae	<i>Centroscymnus coelolepis</i>	Portuguese dogfish	LC

	<i>Centroscymnus owstonii</i>	Owston's dogfish	LC
	<i>Centroselachus crepidater</i>	Longnose velvet dogfish	LC
	<i>Scymnodalatias albicauda</i>	Whitetail dogfish	DD
	<i>Scymnodon plunketi</i>	Largespine velvet dogfish	NT
	<i>Scymnodalatias sherwoodi</i>	Sherwood's dogfish	DD
	<i>Scymnodon ringens</i>	Knifetooth dogfish	DD
	<i>Somniosus antarcticus</i>	Pacific sleeper shark	LC
	<i>Somniosus longus</i>	Little sleeper shark	DD
	<i>Zameus squamulosus</i>	Velvet dogfish	LC
Sphyrnidae	<i>Sphyrna zygaena</i>	Smooth hammerhead shark	LC
Squalidae	<i>Cirrhigaleus australis</i>	Southern mandarin dogfish	LC
	<i>Squalus acanthias</i>	Spiny dogfish	LC
	<i>Squalus griffini</i>	Northern spiny dogfish†	LC
	<i>Squalus raoulensis</i>	Kermadec spiny dogfish†	LC
Torpedinidae	<i>Tetronarce nobiliana</i>	Great torpedo	DD
Triakidae	<i>Galeorhinus galeus</i>	School shark	LC
	<i>Mustelus lenticulatus</i>	Rig†	LC
†Species endemic to New Zealand			
‡Species treated as a visiting population to New Zealand			

735 Table 4. Poorly-known New Zealand chondrichthyan families, where >30% of New Zealand
 736 species were assessed as Data Deficient.

737

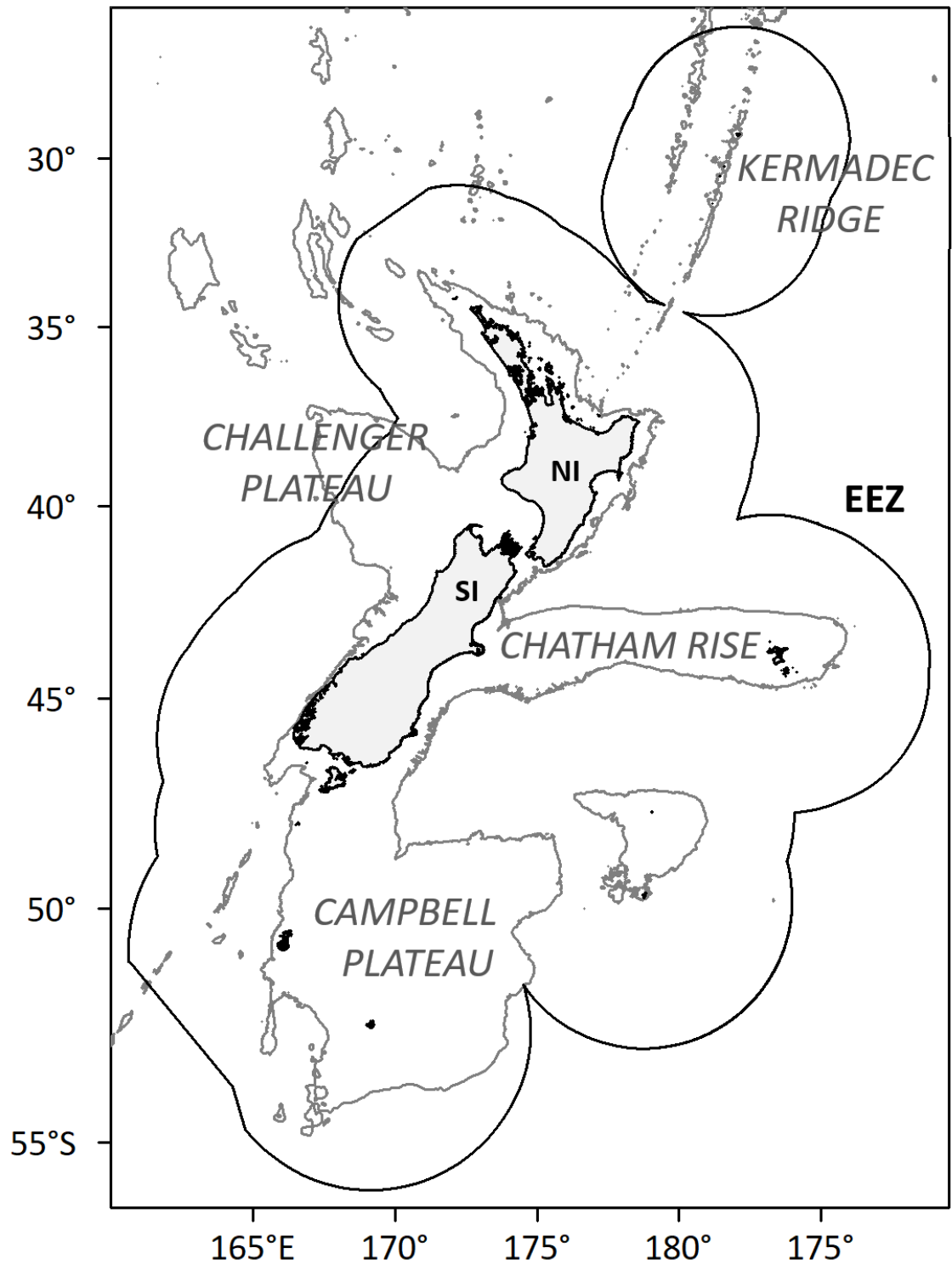
Family	Number of species in NZ	Proportion listed DD
Bramble sharks Echinorhinidae	2	1.00
Torpedo rays Torpedinidae	1	1.00
Goblin shark Mitsukurinidae†	1	1.00
Crocodile shark Pseudocarchariidae†	1	1.00
Softnose skates Arhynchobatidae	13	0.77
Cowsharks Hexanchidae	3	0.67
Gulper sharks Centrophoridae	5	0.60
Sleeper sharks Somniosidae	10	0.50
False catsharks Pseudotriakidae	2	0.50
Thresher sharks Alopiidae	2	0.50
Devilrays Mobulidae	2	0.50
Deepwater catsharks Pentanchidae	8	0.38
† Denotes a globally monospecific family		

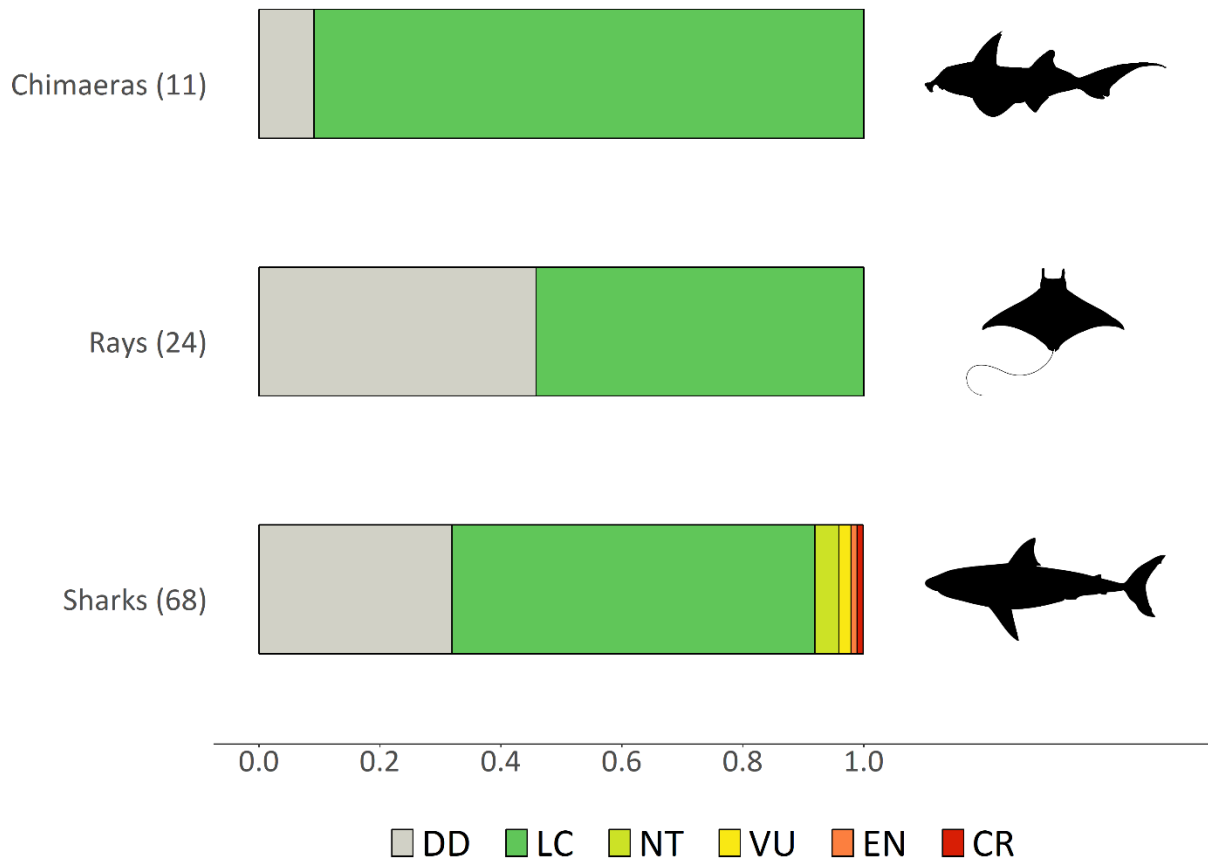
738

739 Table 5. The comparative regional extinction risk of chondrichthyans occurring in New Zealand
 740 (this study), Europe (Nieto et al., 2015), and the Arabian Seas region (Jabado et al., 2017). %
 741 threatened is the sum of the categories VU, EN and CR.
 742

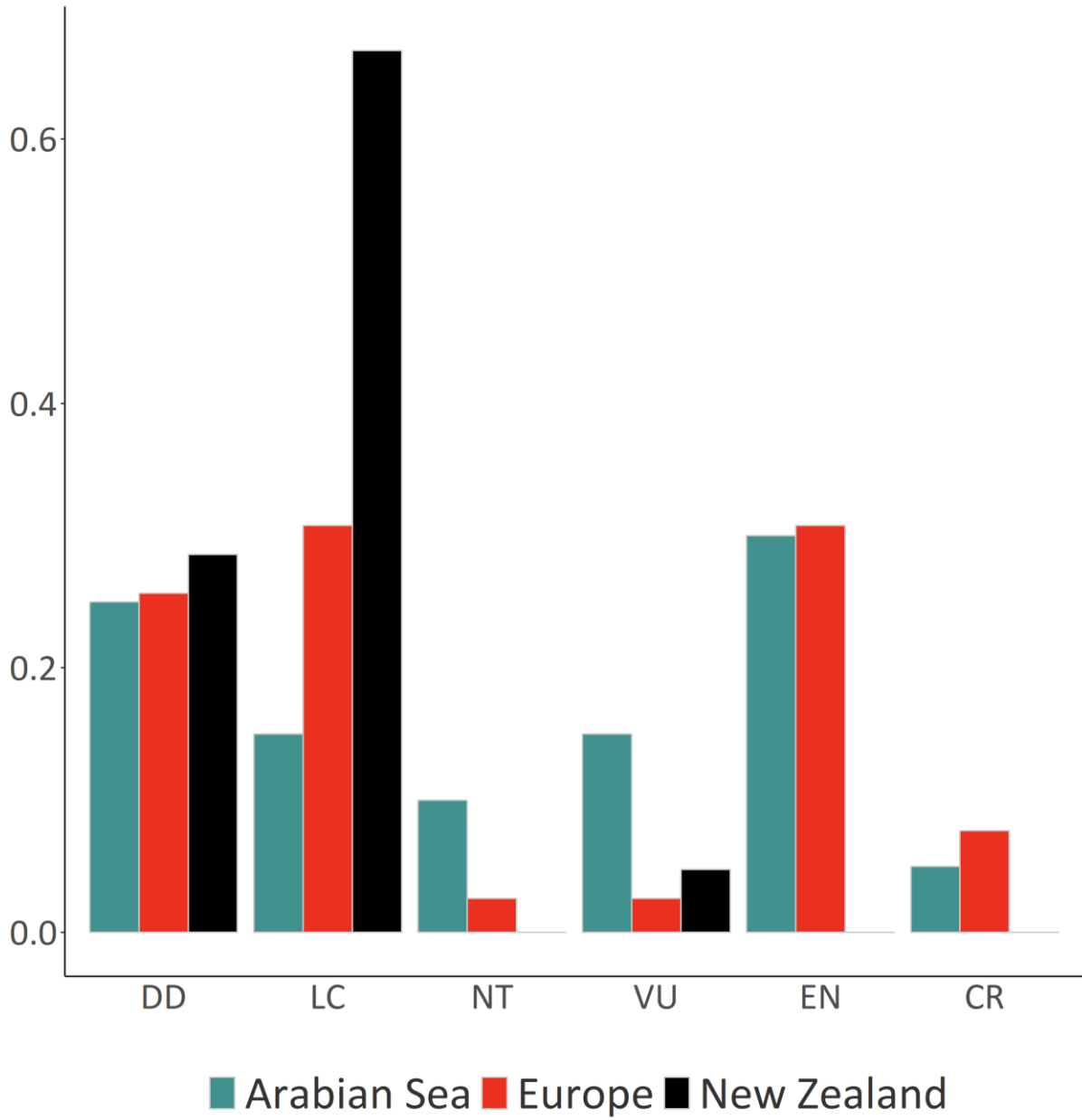
	<i>n</i>	DD	LC	NT	VU	EN	CR	%threatened
New Zealand	103	0.32	0.60	0.04	0.02	0.01	0.01	0.04
Europe	131	0.20	0.37	0.11	0.08	0.13	0.11	0.32
Arabian Seas	153	0.19	0.12	0.18	0.20	0.22	0.09	0.51

743 IUCN Red List of Threatened Species categories: DD, Data Deficient; LC, Least Concern; NT,
 744 Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered.





746



747

748 Appendix I. Comparative global (from IUCN, 2017) and regional extinction risk of widely-
749 distributed chondrichthyans which have been assessed for a combination of New Zealand (NZ;
750 this study), Europe (Nieto et al., 2015), and/or the Arabian Seas region (Jabado et al., 2017).
751 Extinction risk was assessed by applying the IUCN Red List of Threatened Species Categories
752 and Criteria at the regional level.
753

Family	Species	Common Name	Global Status	NZ	Europe	Arabian Seas
Alopiidae	<i>Alopias superciliosus</i>	Bigeye Thresher	VU	LC	EN	EN
	<i>Alopias vulpinus</i>	Thresher Shark	VU	DD	EN	--
Arhynchobatidae	<i>Bathyraja richardsoni</i>	Richardson's Skate	LC	LC	LC	--
Carcharhinidae	<i>Carcharhinus brachyurus</i>	Bronze Whaler	NT	LC	DD	--
	<i>Carcharhinus longimanus</i>	Oceanic Whitetip	VU	CR	EN	CR
	<i>Carcharhinus obscurus</i>	Dusky Shark	VU	NT	DD	--
	<i>Carcharhinus plumbeus</i>	Sandbar Shark	VU	DD	EN	EN
	<i>Galeocerdo cuvier</i>	Tiger Shark	NT	NT	DD	VU
	<i>Prionace glauca</i>	Blue Shark	NT	LC	NT	NT
Centrophoridae	<i>Centrophorus squamosus</i>	Leafscale Gulper Shark	VU	LC	EN	EN
	<i>Deania calcea</i>	Shovelnose Dogfish	LC	LC	EN	--
	<i>Deania hystricosa</i>	Rough Shovelnose Dogfish	DD	DD	DD	--
Cetorhinidae	<i>Cetorhinus maximus</i>	Basking Shark	VU	VU	EN	--
Chlamydoselachidae	<i>Chlamydoselachus anguineus</i>	Friiled Shark	LC	LC	LC	--
Dalatiidae	<i>Dalatias licha</i>	Seal Shark	NT	LC	EN	--
Dasyatidae	<i>Bathytoshia lata</i>	Longtail Stingray	LC	LC	--	DD
	<i>Pteroplatytrygon violacea</i>	Pelagic Stingray	LC	LC	LC	LC
Echinorhinidae	<i>Echinorhinus brucus</i>	Bramble Shark	DD	DD	EN	VU
Etmopteridae	<i>Etmopterus pusillus</i>	Smooth Lanternshark	LC	LC	DD	DD
Hexanchidae	<i>Heptranchias perlo</i>	Sharpnose	NT	DD	DD	LC
		Sevengill Shark				

	<i>Hexanchus griseus</i>	Bluntnose Sixgill Shark	NT	DD	LC	LC
Lamnidae	<i>Carcharodon carcharias</i>	White Shark	VU	VU	CR	--
	<i>Isurus oxyrinchus</i>	Shortfin Mako	VU	LC	DD	NT
	<i>Lamna nasus</i>	Porbeagle	VU	LC	CR	--
Mitsukurinidae	<i>Mitsukurina owstoni</i>	Goblin Shark	LC	DD	LC	--
Mobulidae	<i>Mobula birostris</i> †	Giant Manta Ray	VU	LC	--	VU
	<i>Mobula mobular</i> ‡	Giant Devilray	NT	DD	EN	EN
Odontaspidae	<i>Odontaspis ferox</i>	Smalltooth Sand Tiger	VU	LC	CR	DD
Pentanchidae	<i>Apristurus melanoasper</i>	Fleshynose Catshark	LC	DD	LC	--
Pseudotriakidae	<i>Pseudotriakis microdon</i>	False Catshark	LC	DD	DD	--
Rajidae	<i>Amblyraja hyperborea</i>	Thorny Skate	LC	LC	LC	--
Rhincodontidae	<i>Rhincodon typus</i>	Whale Shark	EN	EN	--	EN
Rhinochimaeridae	<i>Harriotta haeckeli</i>	Smallspine Spookfish	LC	LC	LC	--
	<i>Harriotta raleighana</i>	Longnose Spookfish	LC	LC	LC	--
Somniosidae	<i>Centroscymnus coelolepis</i>	Portuguese Dogfish	NT	LC	EN	--
	<i>Centroselachus crepidater</i>	Longnose Velvet Dogfish	LC	LC	LC	DD
	<i>Scymnodon ringens</i>	Knifetooth Dogfish	DD	DD	LC	--
	<i>Zameus squamulosus</i>	Velvet Dogfish	DD	LC	DD	DD
Sphyrnidae	<i>Sphyrna zygaena</i>	Smooth Hammerhead Shark	VU	LC	DD	EN
Squalidae	<i>Squalus acanthias</i>	Spiny Dogfish	VU	LC	EN	--
Torpedinidae	<i>Tetronarce nobiliana</i>	Great Torpedo	DD	DD	LC	--
Triakidae	<i>Galeorhinus galeus</i>	School Shark	VU	LC	VU	--
† <i>Mobula birostris</i> is currently listed as <i>Manta birostris</i> in the global assessment						
‡ <i>Mobula mobular</i> is currently listed as <i>Mobula japanica</i> in the global assessment						

754 IUCN Red List of Threatened Species categories: DD, Data Deficient; LC, Least Concern; NT,
755 Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered.

