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Author(s)	Thiebot, Jean-Baptiste; Nishizawa, Bungo; Sato, Fumio; Tomita, Naoki; Watanuki, Yutaka
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1 **Albatross chicks reveal interactions of adults with artisanal longline fisheries within a short range**

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3 Jean-Baptiste Thiebot¹, Bungo Nishizawa², Fumio Sato³, Naoki Tomita³, Yutaka Watanuki²

4

5 ¹National Institute of Polar Research, 10-3 Midori-cho, Tachikawa, 190-8518 Tokyo, Japan

6 ²Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1, Minato, Hakodate, Hokkaido 041-8611,

7 Japan

8 ³Yamashina Institute for Ornithology, Konoyama 115, Abiko, Chiba 270-1145, Japan

9

10 Corresponding author: Jean-Baptiste Thiebot. Contact: jbthiebot@gmail.com, ph +81 42 512 0768

11

12 **Abstract**

13 Incidental capture in fisheries (“bycatch”) is a major threat to global marine biodiversity, especially to those
14 species with low fecundity such as albatrosses. Efforts to reduce bycatch have been undertaken in industrial
15 fisheries, however seabird interactions with artisanal, small-scale fleets remain largely unknown. Torishima
16 (Japan) is an important breeding site for two albatross species (short-tailed *Phoebastria albatrus* and black-
17 footed *P. nigripes*), and lies in the range of the artisanal longline fishery for the splendid alfonso *Beryx*
18 *splendens*. In February-March 2017, we GPS-tracked 23 foraging trips of *P. nigripes* feeding chicks, and
19 monitored prevalence of fishing gear at the nests using a metal detector. Albatrosses foraged within 280 km
20 from Torishima, and only 3.7% of the GPS locations occurred over the shallow habitats targeted by the
21 alfonso fishery (150–500 m), suggesting relatively low risks of interaction. However, 190 (54.3%) nests of *P.*
22 *nigripes* contained fishing gear, among which 12 (3.4%) nests or chicks contained a hook or an unidentified
23 metallic object. Six hooks were also collected from *P. albatrus* nests. All found hooks, except one, originated
24 from the alfonso fishery, indicating that both albatross species actually interacted with this fishery at sea. Both
25 approaches provided data from returning birds, and do not reflect possible lethal cases at sea. Monitoring sub-
26 lethal effects of bycatch, and inviting small-scale fisheries to report the gear lost at sea, is desirable to further
27 help quantifying and reducing the impact of fisheries on seabirds.

28

29 **Keywords**

30 Artisanal fisheries; *Phoebastria* albatrosses; seabird-fisheries interactions; longline; bio-logging; Northwest
31 Pacific

32

33 **Introduction**

34 Fisheries are a severe threat to marine biodiversity, impacting ecosystems from the open ocean to the coasts, and
35 from the poles to the tropics (Jackson et al. 2001; Halpern et al. 2008). Commercial fishing has indeed resulted
36 in widespread ecosystem disorders through over-harvesting, habitat degradation and the mortality of non-target
37 species, also called bycatch (Hall et al. 2000). Marine megafauna, including sea turtles, sharks, marine mammals
38 and seabirds, is particularly susceptible to bycatch because these species are attracted to fishery bait and
39 discards, and have naturally low fecundity making their populations sensitive to additional mortality (Brothers
40 1991; Hall et al. 2000; Lewison et al. 2004).

41 Most species of albatrosses worldwide currently face extinction risk, mainly because of fisheries
42 (Anderson et al. 2011; Phillips et al. 2016). Severe declines in albatross populations have notably been caused
43 by unsustainable mortality levels in the longline fisheries (e.g., Weimerskirch et al. 1997), although effective
44 mitigation measures have reduced albatross bycatch in large-scale fisheries in recent years (e.g., Robertson et al.
45 2014). Insufficient data remain however to assess seabird bycatch in many longline fisheries, and this is the case
46 for artisanal, small-scale fleets. Indeed, despite their importance to global catches, small-scale fisheries are often
47 largely unstudied compared to industrial fleets (Lewison et al. 2004; Pauly 2006). In the Mediterranean for
48 example, artisanal longliners can locally have severe impacts on threatened seabirds, as they may implement
49 less or no bycatch mitigation measures compared to semi-industrial pelagic longliners (Belda and Sánchez 2001;
50 Cortés et al. 2017, 2018). Today, major data gaps concern artisanal fleets in West Africa and Northwest Pacific
51 (Anderson et al. 2011).

52 The splendid alfoncino *Beryx splendens* is a commercially important resource in the Pacific side of
53 Japan (Adachi et al. 2000), with annual catches up to 11,000 t. It is exploited year-round with small-scale
54 longliners operating notably along the Izu islands (Takeuchi 2014). In this study we intend to provide a first
55 assessment of at-sea interactions between this small-scale fishery and local albatross populations. In the
56 southern Izu archipelago, Torishima holds about 85% of the global population of the Vulnerable short-tailed
57 albatross *Phoebastria albatrus*, and regionally important numbers of the Near-Threatened black-footed albatross
58 *P. nigripes* (BirdLife International 2018). Both short-tailed and black-footed albatrosses are already known to be
59 at risk of bycatch in industrial fisheries operating in the northern Pacific (Hyrenbach and Dotson 2003; Lewison
60 and Crowder 2003; Suryan et al. 2007; Fischer et al. 2009), but local interactions with artisanal fisheries remain
61 unaddressed. We GPS-tracked black-footed albatrosses breeding at Torishima to quantify the overlap between
62 their at-sea habitat and that targeted by the alfoncino longliners. Concomitantly, we monitored nests of *P.*
63 *nigripes* and *P. albatrus* for the occurrence of fishing gear to reveal actual bird-fishery contacts at sea, and
64 propose options to help reducing these interactions.

65

66 **Materials and methods**

67 Fieldwork was conducted on the western slope of Torishima (Tokyo, Japan; 30.49° N, 140.29° E; Fig. 1), from
68 16 February to 5 March 2017. Black-footed albatrosses arrive at the colonies in mid- to late October, lay an egg
69 between mid-November and mid-December, that hatches from mid-January to mid-February; chicks fledge
70 during June through mid-July, and adults leave the colonies in mid- to late July (ACAP 2010). Short-tailed
71 albatrosses are about 2-3 weeks more precocious (ACAP 2009). GPS loggers (GiPSy5 with 600 mAh battery,
72 TechnoSmart, Italy; dimensions: 45 × 22 × 18 mm; mass: 17 g) were programmed to record location every 20

73 sec, sealed into waterproof heat-shrink tubing, and attached with Tesa ® tape to the back feathers of 18 adult
74 individuals in late chick-brooding (17–26 February). A VHF transmitter (Sakura transmitter LT-04-2, Circuit
75 Design, Inc., Japan; 30 × 11 × 9 mm, 5 g) was also attached on each tracked bird. The signal (150 MHz) was
76 received from > 500 m on a fixed antenna and allowed to increase chances of recapturing the birds on their
77 arrival and to avoid disturbing the study nests with frequent visits for surveying the birds' return. Loggers were
78 retrieved after 3.3 ± 1.1 d on average (range: 1.9–5.2 d), capturing one to several foraging trips at sea. Birds
79 were measured upon recapture to assign sex (Fernández et al. 2001). Three birds could not be recaptured during
80 our stay on the island.

81 From 23 February to 1 March, a total of 350 black-footed albatross nests across seven sub-colonies
82 were examined for the presence of fishing gear (e.g. lines, snoods, hooks). They contained a live chick (n=268,
83 brooded or not), an egg (n=6; incubated or abandoned), and 76 others were occupied by a non-breeding adult or
84 were recently deserted (i.e., not covered with vegetation). Each nest was first visually inspected; a high
85 sensitivity metal detector (Beruf Handy EMD-28, Japan) was then used on the nest surface and the chick's
86 abdomen to reveal metallic objects. It took about one minute to monitor one nest. Nests of short-tailed
87 albatrosses were also monitored at their neighbouring colony, but to avoid disturbing this fragile population nest
88 checks were made by eye only, while visiting the colony for other purposes (e.g., when ringing all 207 chicks on
89 3 March). Whenever possible without excessively disturbing the birds, fishing gear was removed from the
90 monitored nests. Gear found opportunistically at non-monitored nests was noted separately.

91 GPS datasets were downloaded from the loggers and analysed in R 3.4.2 (R Core Team; www.R-
92 project.org), following the framework and scripts provided in Lascelles et al. (2016) with R packages 'sp',
93 'mapproj', 'rgdal', 'adehabitatHR', 'geosphere', 'fields', 'spatstat', 'maps', 'rgeos', and 'mapdata'. All data points at
94 the nest were removed. Kernel density estimations were computed from linearly re-interpolated data (every 10
95 sec). The search radius h for the kernel estimations was based on the scale of the birds' area-restricted search
96 behaviour (45.5 km), calculated from a first-passage time analysis. To examine whether multiple trips made by
97 single birds caused pseudo-replication in the dataset, an iterative measure of the proximity of the trips' core
98 utilisation areas was conducted. This analysis showed that core areas from one individual's multiple trips were
99 not closer than that of trips from different individuals (Mann–Whitney U-tests, $P = 0.43$). Finally, the sample's
100 representativeness was examined by measuring how the population's utilisation core area changed with
101 increased inclusion of data. This asymptotic metric indicated a suitable (88.53%) representativeness of the
102 tracking data for the population's space use. Interpolated locations were mapped over a 1-min bathymetry grid
103 (ETOPO1, Amante and Eakins 2009) to examine the albatrosses' marine habitat use, with the R package
104 'marmap' (Pante and Simon-Bouhet 2013). Differences in trip metrics between sexes were tested using
105 Wilcoxon rank sum test with continuity correction or Welch two sample t-test, depending on whether the
106 variable distribution was significantly different from a normal distribution or not, respectively (assessed from a
107 Shapiro-Wilk normality test). Fisher's exact test for count data was used to compare proportions between groups
108 of birds, nest contents or gear type. For all statistics, differences were considered significant when $P < 0.05$.
109 Values indicated are mean ± SD.

110 The splendid alfonsino mainly uses 200–800 m depth zones with strong bathymetric gradients
111 (Takeuchi 2014; Iwamoto et al. 2015). Demersal longlining targeting alfonsino is operated from small boats off
112 the coasts nearby Tokyo and the northern Izu chain (typically < 5 t with 1–3 men, but up to 5–19 t with 3–7

113 men; setting lines of 50 hooks), and from larger boats in offshore areas including southern Izu chain (50–99 t, 10
114 men; 20 hooks per branch with 60 branches per line; only two boats currently in activity, [Takeuchi 2014](#)).
115 Hooks are set mostly between 150 and 500 m. Fishers of the longliner Housei Maru (targeting alfoncino from
116 Hachijojima, central Izu) helped identifying fishing gear collected at the nests.

117

118 **Results**

119 A total of 27 at-sea trips were collected from 15 black-footed albatrosses (9 females, 6 males). Four trips lasting
120 < 6 h were discarded, as those may reflect unusual activity following logger deployment or recapture attempts.
121 The 23 retained tracks lasted 38.8 ± 17.4 h on average ([Table 1](#)). The furthest location was in the northern sector
122 (within 45° on each side of the North) of the colony for 14 trips, and in the western, southern, and eastern
123 sectors for 4, 3, and 2 trips, respectively. Birds reached a maximum range of 279.3 ± 162.5 km from their nest,
124 covering a total minimum path of 1070.4 ± 635.1 km. Differences between sexes were not significant regarding
125 trip duration ($t_{20,4} = 2.05$, $P = 0.053$), maximum range ($W = 91$, $N = 23$, $P = 0.12$), total distance ($W = 96$, $N =$
126 23 , $P = 0.057$) or proportion of birds heading northward (Fisher's exact test, $P = 0.10$).

127 Kernel density estimations concentrated mainly along the Izu chain ([Fig 1](#)). The birds exploited marine
128 habitats characterized by relatively shallow depths, compared to the available environment: most GPS locations
129 (55.9%) occurred over areas ≤ 2000 m, and frequency of locations was the highest for areas 1000–1200 m deep
130 ([Fig 2](#)). Only 3.7% of the locations occurred in habitats targeted by the alfoncino fisheries (depths 150–500 m).

131 Fishing gear or metallic objects were seen or detected on 190 (54.3%) of the monitored nests of black-
132 footed albatrosses, and at all of the surveyed sub-colonies (20.8–79.3% of the nests in each sub-colony, [Table](#)
133 [2](#)). At 188 nests (53.7%), multi- or mono-filament lines were found, that were not characteristic of any specific
134 fishery ([Fig 3](#)). In eight of these nests, a hook was also detected: six of these hooks were identified as from the
135 alfoncino longline fishery; the two others were broken and could not be identified. Moreover, metallic objects
136 were detected inside four chicks (1.5% of the chicks; see [online video](#)) from three different sub-colonies. Two of
137 these chicks also had fishing lines on their nest. There was no case with both a hook detected on the nest and
138 metal inside the chick. Overall, 3.4% of our survey plot (12 nests, all with a chick, i.e. 4.5% of the nests with a
139 chick) contained a hook or a metallic object, and only 45.7% (160 nests) had no visible fishing gear or detected
140 metal whatsoever. The occurrence of fishing lines on a nest was associated with a significantly greater
141 probability of metal detection at this nest (Fisher's exact test, $P = 0.033$). Nests with a chick were also
142 significantly more likely to contain a hook/metallic object, but not a line or either object (Fisher's exact tests, P
143 $= 0.038$, $P = 0.97$, $P = 0.96$, respectively).

144 Four other hooks were found opportunistically at black-footed albatross nests, all of which originated
145 from the alfoncino longline fishery. One chick was also observed with a hook and line in its bill, which came
146 from this fishery.

147 Six hooks were found on short-tailed albatross nests. Five of them were again identified as from the
148 alfoncino longline fishery; one was larger and probably used in pelagic fisheries. Fishing lines were also seen on
149 the nests, but their occurrence was not quantified.

150

151 **Discussion**

152 GPS tracking of black-footed albatrosses showed that the adults' foraging habitat marginally overlaps with the
153 shallow areas exploited by the artisanal longline fishery for alfonsino: this would suggest a small risk of bird-
154 fisheries interaction. However, nest-based monitoring showed that both black-footed and short-tailed albatrosses
155 do interact at least with this specific fishery at sea, and can transfer fishing gear to their chick. Numerous studies
156 (e.g., [Fischer et al. 2009](#)) rely on the rationale that overlap between the at-sea distribution of fisheries and
157 seabirds can translate into bycatch risks: yet here we show that an expected overlap as small as < 4% was
158 sufficient for adult *P. nigripes* to actually and repeatedly contact fishing gear at sea, although our observations
159 did not account for gear accumulation at the nest over time.

160 Black-footed albatrosses in late chick-brooding foraged within 300 km from Torishima, on average.
161 This is remarkably consistent with conspecifics from the central Pacific Ocean ([Fernández et al. 2001](#);
162 [Hyrenbach et al. 2002](#); [Kappes et al. 2015](#)), and with other subtropical albatross species (e.g. [Thiebot et al.](#)
163 [2014](#)) during chick-brooding. These previous studies indicated however that albatrosses were distributed mostly
164 over oceanic waters > 3000 m deep, and infrequently over shallower continental shelves. In contrast, the black-
165 footed albatrosses from Torishima and nearby Mukojima islands ([Kawakami et al. 2006](#)) selected relatively
166 shallower areas within their foraging radius, putting them at higher risk of contact with small-scale longliners.
167 Especially, birds from Torishima mostly moved northward, *i.e.* to the Tokyo region where the alfonsino small-
168 scale fisheries are primarily based ([Takeuchi 2014](#)). Since seabirds' foraging range varies dramatically across
169 life-cycle stages (e.g. [Thiebot et al. 2014](#)), the risk of bird-fisheries interaction may equally depend on the stage.
170 For instance, stage-dependent analyses have shown that the overlap score with pelagic longliners increased with
171 seabirds' foraging range ([Thiebot et al. 2016](#)). However, in the case of the near-shore fishery for alfonsino, it is
172 likely that the interaction risk is maximal when the albatrosses' foraging range is minimal (during chick-
173 brooding), while this risk would be diluted when the birds spend more time in offshore waters away from
174 Torishima, during larger-scale movement stages.

175 Large-scale patterns of seabird interactions with fisheries are known to vary by sex ([Gianuca et al.](#)
176 [2017](#)): more females are caught in subtropical regions (e.g., [Weimerskirch et al. 2018](#)), but male albatrosses are
177 more likely to ingest marine debris from human activities, including fisheries, than females ([Jiménez et al.](#)
178 [2015](#)). During chick-brooding however, the relatively small foraging radius of albatrosses leads both sexes to
179 temporarily exploit similar areas (e.g. [Hyrenbach et al. 2002](#); [Thiebot et al. 2014](#)), suggesting similar risks of
180 contact with the alfonsino fisheries by male and female *P. nigripes* from Torishima.

181 Albatrosses are able to swallow the baited hooks, or to attack the fish hauled up on the lines; however
182 they cannot break up the line when they are caught, and may thus drown, unless they are cut free by the fishers
183 or have ingested hooks from lost snoods ([Phillips et al. 2010](#); [Thiebot et al. 2015](#)). Hence, the number of
184 interactions indirectly witnessed from nest-based monitoring only reflects the non-lethal cases, after which the
185 birds were able to come back to the nest. Lethal cases possibly occurring at sea could thus not be investigated
186 through our study design. Previous nest-based surveys carried out on several species in the Southern Ocean
187 ([Phillips et al. 2010](#)) show much lower figures than at Torishima. For albatrosses of the genus *Thalassarche*,
188 comparable to *P. nigripes* in their foraging behaviour, fishing gear was found in 0.08% of black-browed *T.*
189 *melanophris* and 0.13% of grey-headed *T. chrysostoma* albatrosses' nests. The considerably higher rate
190 observed at Torishima (54.3%) likely reflects that our rates are un-corrected for inter-annual gear accumulation
191 at the nest (see below). Yet, fishing material occurred in 0.7% of stomach samples from *Thalassarche spp.*

192 chicks, while at Torishima twice this proportion of *P. nigripes* chicks had ingested a metallic object. Hence, the
193 adults from Torishima have an apparent higher rate of interaction with human activities, than southern
194 albatrosses.

195 Metal detected in chicks most likely indicated hooks: other metallic objects at sea would quickly sink
196 out of reach of the birds, while baited hooks or hauled fish can be targeted by the birds near the surface
197 (Brothers 1991). Such detections uncontestedly indicate that the chicks acquired these items after they hatched,
198 while fishing gear at the nest may be accumulated over time and over-estimate bird-fisheries interaction rates.
199 Hence, minimum number of interactions may be estimated, assuming that metal detections (4 over 350 nests)
200 also reflect hooks from the alfonsino fishery, as supported by the chick found among the non-monitored nests
201 with this type of hook. From the 2060 pairs of *P. nigripes* breeding at Torishima in 2013 (reviewed in BirdLife
202 International 2018), at least 24 of them would be in contact with the alfonsino fishery alone, during the 2–3
203 weeks of one chick-brooding season (Kappes et al. 2015). This is a conservative estimate: each chick detected
204 with metal may actually contain several hooks, while other chicks may have regurgitated, or even digested the
205 hooks (suggested in Phillips et al. 2010).

206 Lines were the most prevalent anthropogenic item found at the nests. However, they could not be
207 assigned to any particular fishery. Other fisheries than that targeting alfonsino may operate in the area (such as
208 near-shore or coastal tuna longline fisheries, as supported by the bigger hook found on a short-tailed albatross
209 nest; Fisheries Agency, Government of Japan 2009), as well as yet other maritime activities, from which mono-
210 and multi-filament lines, respectively, could also originate.

211 Guidelines on fishing practices to abate albatross bycatch in industrial fisheries have been described for
212 years (e.g., Brothers et al. 1999; Gilman et al. 2008; Løkkeborg 2011). Recent approaches to protect both
213 wildlife and fisheries productivity against bycatch, have also been developed that are applicable to small-scale
214 fisheries (Cortés and González-Solís 2018). These include automatic photo-monitoring to overcome some
215 deficiencies in observer reports (Bartholomew et al. 2018), and the use of devices such as the ‘Hookpod’ which
216 can be employed conveniently without impairing longline fishing efficiency (Sullivan et al. 2017). In Japan, the
217 small-scale longline fisheries are currently requested to release the seabirds alive when caught, if possible after
218 removing the hooks, and to avoid disposal of offal from the vessel during line setting (Fisheries Agency,
219 Government of Japan 2009). Also, within 20 nautical miles (about 37 km) from Torishima and from October to
220 May, these fisheries have to utilise streaming devices (tori-pole/tori-line) and at least one other mitigation
221 measure (e.g., night-time setting, weighted branch lines). These measures certainly can limit bird-fisheries
222 interactions, nevertheless our study shows that it does not prevent birds breeding at Torishima from ingesting
223 fishing gear. Further approaches should thus be evaluated to tackle this issue. In Japan, c. 98% of fishers are
224 artisanal, and fisheries are co-managed in a decentralized system involving fishers and the government (Matsuda
225 et al. 2010). Under the current Fishery Law, resource conservation is an integral part of resource use, and local
226 resource users are thus the principal decision makers in fishery resource management (Makino and Matsuda
227 2005), especially among coastal fisheries (Matsuda et al. 2010; Tsurita et al. 2018). Hence, this study is central
228 to provide a scientific basis to pursue consultations between fishers, local government and environmental
229 agencies. The alfonsino longline fishers may then need to evaluate which approaches could be best applicable to
230 this fishery. Besides, the relatively small radius of the specially-regulated area around Torishima is one point
231 that may deserve discussion, because our data show that the birds’ foraging range exceeds by far this threshold,

232 even during a stage when this range is presumably minimal in albatrosses (Thiebot et al. 2014). Finally, the
233 option for small-scale fisheries operating near Torishima to report the number of hooks/snoods lost at sea,
234 particularly those due to seabirds, could be debated as well in order to better evaluate the impact of bird-
235 fisheries interactions both on wildlife and fisheries.

236 Artisanal, small-scale fisheries may severely threaten seabirds (Anderson et al. 2011; Cortés et al.
237 2017, 2018). In the Northwest Pacific, our study showed that albatrosses contact fishing gear from at least one
238 artisanal fleet during the breeding period, when their foraging range is relatively short. Longer-term monitoring
239 is nevertheless needed to better assess the local environmental risks posed by artisanal fisheries. Notably,
240 removing all hooks and fishing lines/gear found from one visit to the next would allow to quantify (1) the annual
241 rate of bird-fishery interactions; (2) the influence of breeding stage, and hence foraging range, on the fisheries
242 contacted by the birds; and (3) the effectiveness of new regulations or fishing practices (Phillips et al. 2010;
243 Løkkeborg 2011). Simultaneous tracking of the birds at sea, using the innovative approach from Weimerskirch
244 et al. (2018), in which GPS loggers with radar-detection system enable to quantify bird-vessel interactions at
245 sea, would be particularly helpful to refine risk assessments. Future studies at the nest may further aim at
246 quantifying sub-lethal effects on the birds interacting with this small-scale fishery. Sub-lethal effects of bycatch
247 may be considerable (Wilson et al. 2014), and encompass alteration of reproduction, feeding, and/or growth
248 (*i.e.*, fitness) for animals that survived a fisheries interaction. For albatrosses, ingesting bait and hooks may
249 cause such effects. It is thus desirable to measure growth in chicks; breeding success, frequency and mass of
250 meals fed in adults; and stress response and immune defences in both, as a function of fishing gear prevalence.
251 All these effects can indeed occur undetected following escape or release from fishing gear, while having
252 significant consequences at the population or ecosystem-level on the longer-term (Wilson et al. 2014).

253

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257

258 **Compliance with ethical standards**

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262 **Conflict of interest** The authors declare that they have no conflicts of interest.

263 **Ethical approval** All applicable international, national, and institutional guidelines for the care and use of
264 animals were followed. Permits to capture and tag birds on Torishima were obtained through the Japan Ministry
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266 approvals were obtained through Hokkaido University.

267

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- 383

384 **Figure Legends**

385

386 **Fig. 1** Kernel density estimations (95% and 50% contours: yellow thin and thick lines, respectively) of black-
387 footed albatrosses GPS-tracked from Torishima (white triangle), southern Izu islands. Background shows
388 bathymetry from dark grey (deep areas) to white (emerged areas) and the maximum isobath where the alfonsino
389 fisheries operate (thin black line: 500 m) (colour figure online)

390

391 **Fig. 2** Frequency distribution of the seafloor depth within: the birds' average foraging range (upper panel); the
392 birds' exploited habitat (lower panel). Red dashed lines indicate lower (-500 m) and upper (-150 m) depths at
393 which the alfonsino fisheries operate (colour figure online)

394

395 **Fig. 3** Illustration of the nest survey steps: (a) visual search: in this case, fishing lines can be seen on the nest;
396 then a metal detector is used to search (b) from the nest perimeter to its centre, and (c) on the chick's abdomen;
397 (d) example of a hook from the alfonsino fishery (scale in cm). Pictures taken by JB Thiebot (colour figure
398 online)

399

400 **Table 1** Trip metrics (angles: 0 or 360° correspond to North). The four trips marked with asterisks were
 401 excluded from all analyses, due to their very short duration (< 6 h). Sex inferred from biometry is indicated for
 402 each individual (F: female; M: male)
 403

Bird ID (Sex)	Trip ID	Duration (h)	Maximum Range (km)	Mean Speed (m s ⁻¹)	Total Distance (km)	Direction of the furthest point (°)
31 (F)	1	43.7	239.5	7.18	1067.6	344.01
32 (M)	2	27.7	262.5	7.08	684.9	329.68
32 (M)	3	17.8	49.6	4.11	181.2	184.43
32 (M)	4	42.3	283.5	7.67	777.0	339.12
32 (M)	5	22.9	225.4	7.52	583.6	261.00
33 (F)	6***	2.1	6.5	5.92	33.4	349.60
33 (F)	7	38.6	416.8	9.77	1351.9	341.27
33 (F)	8***	0.6	5.5	8.45	19.6	287.96
33 (F)	9	57.7	505.2	9.90	1962.5	2.03
34 (M)	10	44.2	303.8	5.76	879.6	319.53
35 (F)	11	26.4	173.4	9.88	484.3	333.12
35 (F)	12	24.1	176.8	10.57	576.2	338.83
36 (F)	13	41.1	282.3	6.89	895.2	35.40
36 (F)	14	17.5	171.3	6.01	394.9	336.15
39 (F)	15	43.3	424.5	10.32	1560.5	334.95
41 (M)	16	21.2	98.7	8.13	611.4	267.27
42 (F)	17	24.7	293.4	9.70	859.3	75.69
42 (F)	18	73.5	465.2	8.77	2294.3	339.05
42 (F)	19***	4.8	39.4	7.98	138.7	72.40
43 (M)	20***	5.9	26.6	9.35	198.9	290.25
43 (M)	21	41.3	223.4	6.99	1024.7	248.79
44 (F)	22	63.3	797.2	12.06	2740.8	19.48
46 (M)	23	27.6	362.2	12.42	1206.5	340.17
46 (M)	24	17.6	152.4	8.66	539.3	191.44
48 (F)	25	50.1	174.4	7.12	1277.7	78.93
49 (F)	26	76.3	201.9	6.48	1755.6	248.64
50 (M)	27	50.3	140.0	5.11	910.3	172.14
MEAN		38.8	279.3	8.2	1070.4	NA
S.D.		17.4	162.5	2.1	635.1	NA

404

405 **Table 2** Summary of nest monitoring per sub-colony plot of black-footed albatross on Torishima. Between
 406 brackets are detailed the numbers per nest content (chick/egg/inactive)
 407

Sub-colony plot	Number of nests	Nests with lines	Nests with hook	Chicks with detected metal
Solar panel	6 (4/1/1)	2 (1/0/1)	1 (1/0/0)	0
Southernmost Ridge	24 (19/1/4)	5 (4/0/1)	1 (1/0/0)	0
Southernmost Ridge to Southern Ridge	40 (28/3/9)	21 (11/2/8)	1 (1/0/0)	1
North of counting viewpoint	29 (21/1/7)	23 (16/1/6)	0	0
South of counting viewpoint	110 (77/0/33)	59 (44/0/15)	1 (1/0/0)	1
Ōiwa	70 (59/0/11)	35 (27/0/8)	1 (1/0/0)	0
Matsu Ridge	71 (60/0/11)	43 (34/0/9)	3 (3/0/0)	2
Total	350 (268/6/76)	188 (137/3/48)	8 (8/0/0)	4

408

409 **Electronic supplementary material**

410

411 (Video) A case of detected metal inside a chick. The observer (B Nishizawa) first tests the sensitivity of the

412 metal detector on his wristwatch, then checks the area around and inside the nest, and finally passes the detector

413 against the chick's belly. Video taken by JB Thiebot

Fig. 1

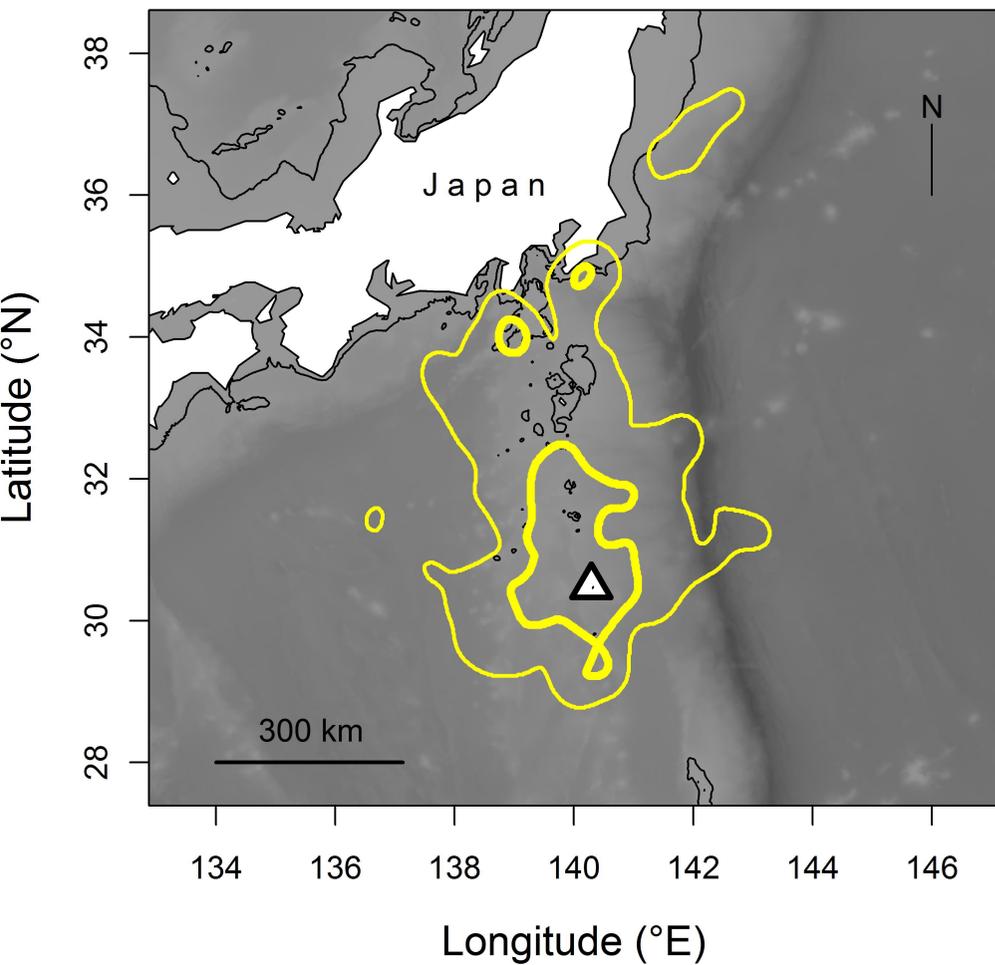


Fig. 2

