Mapping the distribution of scale-rayed wrasse *Acantholabrus palloni* in Swedish Skagerrak using angling records

Joacim Näslund Corresp., 1 , **Markus Lundgren** 2

1 Department of Zoology, Stockholm University, Stockholm, Sweden

2 Swedish Anglers Association, Gothenburg, Sweden

Corresponding Author: Joacim Näslund
Email address: joacim.naslund@gmail.com

In this paper, we map the distribution of scale-rayed wrasse *Acantholabrus palloni* in eastern Skagerrak based on a combination of verified and personally communicated angling records. A recent surge in verified angling records in the Swedish Anglers Association's specimen database *Storfiskregistret* provides information to suggest that this species should no longer be considered an occasional guest, but rather a species established in the Swedish parts of Skagerrak. These records are supported by additional personal communications with anglers. The species is currently well spread geographically along the Swedish Skagerrak coast, with many locations providing repeated captures of adult fish over multiple years. The typical Swedish catch sites are rocky reefs located between the general 40-m and 80-m depth curves, likely influenced by currents bringing higher-salinity water from the North Sea. The present study show that angling records can provide an important, but underutilized, resource for mapping the distribution of data-deficient fish species.

1 # Mapping the distribution of scale-rayed wrasse

2 # *Acantholabrus palloni* in Swedish Skagerrak using angling

3 # records

6 **Joacim Näslund[1]* and Markus Lundgren [2]**

9 1. Department of Zoology, Stockholm University, Stockholm, Sweden

10 2. Swedish Anglers Association, Gothenburg, Sweden

11 *Corresponding author: joacim.naslund@gmail.com

13   ABSTRACT

15   In this paper, we map the distribution of scale-rayed wrasse *Acantholabrus palloni* in eastern

16   Skagerrak based on a combination of verified and personally communicated angling records. A

17   recent surge in verified angling records in the Swedish Anglers Association's specimen database

18   *Storfiskregistret* provides information to suggest that this species should no longer be considered

19   an occasional guest, but rather a species established in the Swedish parts of Skagerrak. These

20   records are supported by additional personal communications with anglers. The species is currently

21   well spread geographically along the Swedish Skagerrak coast, with many locations providing

22   repeated captures of adult fish over multiple years. The typical Swedish catch sites are rocky reefs

23   located between the general 40-m and 80-m depth curves, likely influenced by currents bringing

24   higher-salinity water from the North Sea. The present study show that angling records can provide

25   an important, but underutilized, resource for mapping the distribution of data-deficient fish species.

BACKGROUND

Records of rare species and their natural history can constitute important information for future research on these species and the ecosystems they occur in, e.g. with respect to human impacts (Boero 2013; Able 2016). Obtaining records of rare species is, however, time consuming and professional biologists are often active within projects limited in time and space, making alternative sources for information important (Devictor, Whittaker & Beltrame 2010; Bradter et al. 2018). This is particularly true for records from aquatic environments, where the occurring species rarely can be observed directly, but rather have to be obtained by indiscriminate techniques such as trawls, nets, and dredges, which are also limited in their areal coverage at any given point in time. To achieve a larger spatial and temporal coverage, there is typically need for larger efforts and manpower than normally possible within a normal research project. Non-professional experts can help in the collection of species occurrence data, a feature which has been widely utilized for a long time within the scientific field of ornithology (Silvertown 2009; Dickinson, Zuckerberg & Bonter 2010; Bradter et al. 2018). However, non-biologists well versed in species determination, -ecology and -distributions, exist not only for birds, but also for fish in the form of leisure anglers (e.g. Granek et al. 2008). Angling is a common leisure activity in large parts of the world (Arlinghaus, Tillner & Bork 2015; Hyder et al. 2018) and anglers often document (photographs and personal journals; e.g. Banha, Ilhéu & Anastácio 2015; Skov, Jansen & Arlinghaus 2017) and report their catches (public or closed databases; e.g. Venturelli, Hyder & Skov 2017; this paper: Materials and Methods). Some anglers are also specializing in 'collecting' different species [a similar concept to 'twitching' in the bird-watching community; see e.g. the Swedish online angling community '50-klubben' ('The club of 50 species'), http://www.50klubben.se/]. Information about rare species' occurrence is also commonly spread openly within the angler community (Lundgren

50   & Waje 2015) Hence, anglers' records and notes are excellent sources for confirmed qualitative

51   data on presence of species in certain areas and can be useful and important, but underutilized,

52   auxiliary and corroborating sources for mapping distributions and habitats of data-deficient species

53   (e.g. Fetterplace et al. 2018). In this paper, the aim is to present a desktop study where citizen-

54   generated data, in the form of private and publicly available angling records, are used to map out

55   a tentative distribution map for a data-deficient species, the scale-rayed wrasse *Acantholabrus*

56   *palloni* (Risso, 1810), in Swedish waters.

57   *Acantholabrus palloni* is a labrid fish inhabiting the eastern Atlantic Ocean and the Mediterranean

58   Sea, with a known latitudinal range from Gabon in western Africa to mid- Norway, including areas

59   around some of the eastern Atlantic offshore islands, like Madeira and the Canary Islands

60   (Andersson 1942; Debelius, 1997; Muus, Nielsen & Svedberg, 1999; Pollard, 2010; Kullander et

61   al. 2012). The full range of the species is continuously being mapped out, with relatively recent

62   documented records from e.g. the Azores and Cape Verde Islands (Santos, Porteiro & Barreiros,

63   1997; Wirtz et al. 2013). The species is considered rare throughout its known range, but since its

64   typical habitat (coralline and rocky offshore reefs) are seldom trawled, its population may be

65   underestimated due to lack of capture records (Swaby & Potts 1990; Pollard 2010). Little is known

66   about its ecology; it is considered to live solitarily or in small groups, and the diet mainly consists

67   of benthic invertebrates (Pollard 2010). It is light brown in colour and characterized by one black

68   blotch on the posterior part of the dorsal fin, a black blotch on the dorsal part of the trunk and

69   several lighter blotches on the back, below the dorsal fin. By these characteristics, the species is

70   well distinguished from other wrasse species in Swedish waters. In the Mediterranean Sea it is

71   often found on rocky bottoms at depths below 80 m (Sartoretto *et al.* 1997). In the northern parts

72   of its range, however, it has been noted at shallower depth (from 18 m; Debelius, 1997; Kullander

73   *et al.*, 2012).

74   In Norway, the species has been considered rare, albeit potentially yearly in occurrence (Curry-

75   Lindahl 1985), but recent evidence suggest that there are larger concentrations of the species in

76   e.g. the Hardangerfjord, and anecdotal reports from scuba-divers suggest it is more common than

77   previously thought (Espeland *et al.*, 2010). The species is regularly captured by anglers in the

78   Norwegian part of northern Skagerrak, just south of Langesund, on rocky bottoms at 40 to 60 m

79   depth, elevating from deeper soft bottoms (Fig. 1., position 1; M. Lundgren, personal observations;

80   also documented in the catch-records of the Langesund Seafood and Fishing Festival;

81   http://www.lsff.no/; data accessed 2014-04-23). The first recorded Scandinavian specimen

82   (recorded as *A. Couchi*) was retrieved in 1869 from around 50 meters depth in the area around the

83   island Hidra (Hitterø) close to Flekkefjord in south-western Norway, and is preserved at the

84   Swedish Museum of Natural History (cat. no. NRM 47556) (Öberg 1870; SMNH 2018; description

85   reiterated in Stuxberg 1894). This specimen was confirmed as an adult individual belonging to the

86   species *Labrus palloni* (junior synonym to *A. palloni*) by Lilljeborg (1881). Another three

87   preserved specimens from the Norwegian parts of the eastern Skagerrak (captured in 1966, 1968

88   and 1985), around the southern parts of the Oslofjord area (Fig. 1., one specimen at position 2, and

89   two specimens at position 3), are available at the Natural History Museum, University of Oslo,

90   according   to   the   Global   Biodiversity   Information   Facility   (GBIF)   database

91   (https://www.gbif.org/). In addition, Andersson (1964) notes that a few specimens had been caught

92   between Stavanger and Kristiansand in Norway.

93   While the presence of *A. palloni* along the southern Norwegian coast is clearly documented with

94   sporadic, but repeated, records over the last century, the eastern limits in the Skagerrak are not

95   well established. The species has been noted as not being native to Swedish waters (Pethon &

96   Svedberg, 2004; Nielsen & Svedberg 2006; Pollard, 2010; Craig & Pollard 2015), or alternatively,

97   only being present in the Koster Fjord area (Nilsson, 1997; Fig. 1, position 4). Whereas FishBase

98   (http://www.fishbase.org/; Froese & Pauly 2018) lists the species as native, based on the Swedish

99   checklist of fishes (Kullander 1999); this checklist, however, lists all species recorded in Swedish

100 waters, including sporadic visitors. In an updated checklist, the occurrence of *A. palloni* is noted

101 as "sporadic" (Kullander 2002). The FishBase-associated AquaMaps project

102 (http://www.aquamaps.org/; Kaschner *et al.*, 2016) has a predicted occurrence probability of 0.60-

103 0.79 in Swedish waters (Kesner-Reyes *et al.*, 2016), based on a single verified and a few unverified

104 records in GBIF (the single verified record, from southern Skagerrak, is noted here in the Results

105 section). Recently, the distribution of the species has been suggested to be wider than previously

106 thought in Swedish waters, based on multiple reports of angled specimens.

107   MATERIALS AND METHODS

108   *Swedish non-angling records (1993-2016)*

109   Non-angling records were sourced from the scientific literature (Cedhagen & Hansson 1995;

110   Hallberg 2011), the Swedish Species Observation System (SSOS; http://www.artportalen.se/), and

111   the GBIF-Sweden Data Portal (http://www.gbif.se/).

112   *Swedish angling records (1995-2016)*

113   The majority of the angling records were obtained from the curated specimen registry

114   (*Storfiskregistret*) of the Swedish Anglers Association (SAA; http://www.sportfiskarna.se/), where

115   anglers can report catches of fish specimens above a certain species-specific mass-limit, which

116   then gets validated based on photographs, accessory information, and, if needed, expert

117   assessment. The SAA records contains additional information about capture location, depth,

118   habitat, and capture method. The mass-limit for recording an *A. palloni* in the SAA specimen

119   registry is 250 g (effective since 2012; before that it was 300 g, but no registered records exist

120   from this time-period).

121   Additional records, were supplied by Swedish anglers, located through posts on internet blogs or

122   through personal communication. A number of records are also direct personal observations by

123   the authors (e.g. specimens in Figure 2). Furthermore, some records in the SAA registry had

124   limited capture information. In such cases, the angler was contacted.

125   All records from the SAA database in Table 1 have been verified by the authors from photographs.

126   SAA carries digital copies of all fish in their records. Personal communications were obtained

127   from experienced sea anglers; some of these records are unverified (see Table 1) and should

128   therefore be used mainly as auxiliary information. While misidentification of the species is

129   possible, specimen sea anglers are typically examining their catch closely when resembling a rare

130   species. Hence, the unverified angling records are judged to be valid.

132   RESULTS

133   *Swedish non-angling records*

134   The occurrence of *A. palloni* in Swedish waters was rarely reported prior to 2010, with a first

135   record of a juvenile specimen from year 1993 from somewhere between 50 and 115 m depth in

136   the mouth of the Singlefjord, northeastern Skagerrak (Cedhagen & Hansson, 1995; Fig. 1., position

137   5). The species has also been previously reported from the Koster Fjord area around the Koster

138   Islands, northeastern Skagerrak, (Fig. 1, position 4; Hallberg, 2011) and 6 km west of Rörö Island

139   (Fig 1., position 6), southern Skagerrak in 2008 (data provided by Swedish Museum of Natural

140   History, Stockholm; accessed through GBIF-Sweden Data Portal, 2014-04-25; also reported as

141   capture site by Palmkvist *et al*., 2016). Only two unverified observations were found in SSOS (as

142   of 2018-05-22). The first record comes from Persgrunden (Fig. 1, position 7), stemming from a

143   scientific transect investigation using a remotely operated vehicle in 2007; the second is a

144   questionable record from the harbor of Käringön. The latter record (record 54966014 in SSOS) is

145   not reported in Table 1, due to *A. palloni* not being a typical species seen in the shallow harbor

146   waters [in contrast to the similar looking goldsinny wrasse *Ctenolabrus rupestris* (L.)].

147

148   *Angling records*

149   Between the first Swedish record in 1993 (Cedhagen & Hansson 1995) and 2011, a few angling

150   records of *A. palloni* were noted from different sites on the Swedish west coast (Table 1). Between

151   2011 and 2016, several records of *A. palloni* have been provided by leisure anglers (Table 1).

152   Repeated captures of the species have been made across years, at least at a few positions (e.g.

153   position 9; Table 1).

154   Most angled specimens are reported to be caught on, or directly above, rocky bottom at depths of

155   28-50 m. Another specimen standing out from the rest is record #16 which is the only one caught

156   inshore (in the Gullmarn Fjord, Fig 1, Position 11), apart from the first Swedish record by

157   Cedhagen & Hansson (1995).

159   DISCUSSION

160   The presented records extend the knowledge about the marine ichthyofauna of eastern Skagerrak,

161   which is a generally well documented area regarding fish species distributions (Kullander *et al.*,

162   2012). In the light of the present summary of these records, we show that angling databases can be

163   utilized as a source for information about the distribution of fish species which are seldom targeted

164   by commercial fisheries, but specifically targeted by anglers.

165   *Acantholabrus palloni belongs to the Swedish ichthyofauna*

166   The angling records of *A. palloni* show that several individuals of this species being repeatedly

167   caught in the same general locations, at multiple sites, in Swedish waters. It should be noted that

168   number of angled specimens at any given position are likely related to the specific fishing pressure

169   at that site, and data are limited to adult specimens as a consequence of the size-restrictions in the

170   SSA database (see Materials and Methods). Still, these repeated captures across several years

171   indicate that *A. palloni* could be currently established in, at least some, areas of eastern Skagerrak.

172   Notably, the sites at which the species is recorded, matches the 40-80 m depth curve in Skagerrak,

173   as well as the currents from the North Sea which bring higher-salinity water into the southern

174   Skagerrak and northwards along the Swedish coast (Svansson, 1975; Fig. 1). It is worth noting that

175   the current list of records (Table 1) is not a complete record of angled *A. palloni*, as several other

176   specimens (typically smaller ones) have been verbally described to the authors by anglers, without

177   any specific information being noted by the angler.

178   *Spatial and temporal distribution of the population*

179   The typical capture site for *A. palloni* is rocky reefs located largely within the general 40 – 80-m

180   depth range along the Swedish Skagerrak coast. Capture sites are also matching the route of the

181   main currents bringing water from the North Sea. The bottom layer of the deeper parts of Skagerrak

182   have a salinity similar to the North Sea and is substantially more saline than the water originating

183   from the Baltic Sea in the upper layers and in Kattegatt to the south of Skagerrak (Svansson 1975).

184   This likely makes the conditions in these areas suitable for marine species with a main distribution

185   area in more saline waters, such as *A. palloni*.

186   The presence of the species at the offshore islands of the Atlantic (the Azores, Canary Islands,

187   Madeira and Cape Verde) suggests that there is capacity for dispersal in the species. However, the

188   temporal aspect of dispersal appears largely unknown. The angled specimens are all captured

189   between May and October, which represents the time when the angling activity is highest. Given

190   paucity of data from the winter-months, we cannot exclude that the species is a seasonally

191   migratory species in this geographic area. An additional unverified underwater observation was

192   made in November during a scientific expedition at Persgrunden (record #4; Table 1); but

193   November-temperatures at >25 m depth largely matches spring- to early-summer temperatures

194   (Svansson, 1975), so such an observation does not indicate a non-migratory behaviour. However,

195   given the apparent strong reef-association, the small body size, and the labriform swimming mode,

196   which is relatively inefficient for long-distance swimming (Sfakiotakis, Davies & Lane, 1999), a

197   seasonal migratory life-style seems unlikely. Notably, Craig and Pollard (2015) states that it is not

198   a migratory species; however, without explicit support from data or references.

199   *Stability of the population*

200   The first Swedish record was a juvenile individual (Cedhagen & Hansson, 1995), which is

201   indicative, but not proof, of spawning in the area. It could be possible that Skagerrak acts as a sink

202   for the *A. palloni* population, with fry or young individuals drifting into the Skagerrak area from

203 the North Sea and then settling on suitable rocky reefs. Until spawning and viable fry can be

204 demonstrated from Skagerrak, it is not possible to know whether the Skagerrak population is self-

205 reproducing. Systematic investigations of angled specimens (e.g. in association with marine

206 angling competitions) could provide information about spawning activity, as well as other aspects

207 of their biology, such as feeding habits and parasite fauna – all of which are largely unknown for

208 the species (Kullander *et al.*, 2012). Studies on population genetics may provide further insights

209 into the population structure of the species (see e.g. Faust *et al.*, 2018). Hence, such investigations

210 could be encouraged to extend the knowledge of this data-deficient species.

211 *Range extension due to climate change?*

212 The recent surge in records could be an indication of a range extension. One hypothetical factor

213 that could lead to range extensions is the changing climate which leads to higher seawater

214 temperatures (Dye *et al.*, 2013). While increased sea water temperature was also noted from 1939

215 to 1960, the warming effect has been particularly strong in the north-east Atlantic during the last

216 decades (Dye *et al.* 2013). The estimated temperature increase in Skagerrak, from 1990 to 2014,

217 is 1.6°C (Rinde, Hjermann & Staalstrøm, 2016). Range extensions has indeed been indicated in

218 several European marine areas, including Scandinavian waters (Hiddink and ter Hofstede, 2008;

219 Nicolas *et al.*, 2011; Brattegard, 2011). Brattegard (2011) estimated that more than 500 marine

220 benthic species expanded their range northwards in Norwegian waters, in the range of 750-1000

221 km, between 1997 and 2010. Furthermore, several new species were found to establish along the

222 Norwegian Skagerrak coast during this time (Brattegard, 2011; Rinde *et al.*, 2016). Even though

223 the angling records are located south of the previous northern range limit, the eastern Skagerrak is

224 still at the edge of the species' northern distribution range (AquaMaps presents an estimated native

225 distribution map that extends to the Faroe Islands, but this is not supported by actual records of the

226 species [Kaschner et al., 2016; Kesner-Reyes et al., 2016)]. Hence, a climate-related population

227 increase at the northern distribution range may cause spillover effects into the Swedish waters of

228 Skagerrak, following the main currents in this area (cf. Fig. 1 and Rinde *et al.*, 2016). However,

229 the paucity of historical data on the species makes it impossible to conclude whether this is the

230 case or not. The fact that the species was recorded in south-western Norway already in 1869

231 (Öberg, 1870), with further observations along the south coast of Norway noted prior to 1942

232 (Andersson, 1942), suggests that it was present, at least temporarily, close to Swedish waters prior

233 to the recent increase in the seawater temperature. It is also very hard to distinguish climate effects

234 from other effects such as fishing or meta-population dynamics (Brander and Havenhand, 2016).

235 *Prior records missing due to historical angling methods and oversight?*

236 *Acantholabrus palloni* is generally captured over off-shore rocky reefs. Smaller-sized marine fish

237 species, such as *A. palloni*, have historically not been targeted by off-shore anglers to the same

238 extent they currently are (Lundgren & Waje, 2015). While coastal anglers use a wide variety of

239 hook-sizes, off-shore anglers have, until recently, mainly used larger hooks targeting larger

240 species. With the relatively small gape-size of *A. palloni*, this may effectively have eliminated the

241 species from being caught, even though the capture sites reported here have been commonly

242 targeted reefs for angling (Lundgren & Waje, 2015). In addition, the typical rocky reef habitat is

243 likely seldom trawled by commercial fishermen, probably leading to few specimens being caught

244 in fisheries overall (Pollard, 2010). While clearly distinguished at closer inspection (which is

245 typically what specimen sea anglers do), it also resembles the common goldsinny wrasse and

246 young female cuckoo wrasse *Labrus mixtus* L. in coloration, which may lead to misidentification

247 and oversight by e.g. fishermen not interested in the species for commercial purposes. These facts

248 may have limited the number of captures and historical reports from Swedish waters. Similar

249   oversight might apply to other rare Scandinavian species, such as *Thorogobius ephippiatus* (Lowe,

250   1839) and *Pomatoschistus norvegicus* (Collett, 1903) (Holm & Mattson, 1980; Cedhagen &

251   Hansson, 1995).

252   *Value for Swedish fisheries*

253   Despite its relatively small size, *A. palloni* has value for marine specimen angling, e.g. in marine

254   angling competitions where the number of species caught is rewarded. In fact, the angling records

255   being presented in this article are largely a consequence of this species being acknowledged as a

256   target for specimen anglers, who are specifically targeting large specimens of different species

257   (e.g. Hellenberg, 2014a,b; Lundgren & Waje, 2015). In commercial fisheries, however, it has

258   generally little or no value (Machias *et al.*, 2001; Nielsen & Svedberg 2006), although it has been

259   noted among the targeted species in some Mediterranean countries (e.g. Alegre, Lleonart & Veny,

260   1992; Economidis & Koutrakis, 2001). Smaller wrasse species are fished commercially in

261   Scandinavia for sea lice control in salmon farms (Espeland *et al.*, 2010), but *A. palloni* is not suited

262   for such fishery as it is deeper-living than most of the other smaller wrasses [e.g. corkwing wrasse

263   *Symphodus melops* (L.) and juvenile ballan wrasse *Labrus bergylta* Ascanius, 1767] and, thus,

264   generally subjected to severe barotrauma when hauled, resulting in inflated swim-bladders and

265   bulging eye-balls (see e.g. Fig. 2).

266   *Using angling records for conservation and management of rare fishes*

267   This study presents a case where citizen generated data can be used for increasing the knowledge

268   about a rare species. It is possible that recognition of the angler community as a valuable source

269   of information may increase anglers' interest in continuing and increasing the frequency and detail

270   of their reports. Anglers are often keen to participate in the management of fish stocks, but may

271   also be skeptical about revealing the exact location of their fishing sites, so this type of recognition

272   may lead to a further increased interest in fish conservation issues (Granek et al., 2008; Fetterplace

273   et al. 2018). From a conservation and management perspective, the current data provides a

274   tentative picture of the distribution and habitat in Swedish waters. A quantitative habitat suitability

275   model (HSM) is, however, not possible to construct, mainly due to the scarcity of data about habitat

276   conditions at capture sites. Bradter et al. (2018) constructed HSMs for Siberian Jays in Sweden,

277   utilizing data from the SSOS. As compared to e.g. birds, for which the SSOS reporting system is

278   run in collaboration with BirdLife Sweden (the Swedish Ornithological Society), fish appear to be

279   under-reported in SSOS. Hence, the SAA database appears to be substantially more informative

280   and reliable for observational reports of fish at the present point in time, despite having a lower

281   mass-limits for reports, which limits the number of reports in general and completely eliminates

282   reports of juvenile specimens.

284 CONCLUSIONS

285 In this article, we summarize the present knowledge about the current distribution of *A. palloni* in

286 Swedish waters, at the edge of the distribution range of the species. The records of *A. palloni*

287 presented here in particular highlight the importance of citizen-generated data in the form of

288 anglers' reports and angling records as useful contributions for ichthyological investigations of

289 presence and distribution of non-commercial fish species.

290

291 ACKNOWLEDGEMENTS

292 We thank Magnus Durell, Mattias Jonsson, Mattias Liewendahl, Arvid Enemar and Dan Calderon

293 for providing details on their catches of scale-rayed wrasse. Nicka Hellenberg is thanked for

294 curating the *Storfiskregistret* specimen database. Three anonymous reviewers are thanked for

295 contributing valuable comments and information.

296 ETHICAL APPROVAL

297 This article does not contain any direct studies with animals performed by any of the authors.

298 SAMPLING AND FIELD STUDIES

299 Fish specimens reported were caught following Swedish or Norwegian angling regulations. All

300 cases where the authors captured recorded specimens were part of non-scientific angling

301 expeditions, conducted prior to the conception of the study.

303   REFERENCES

304   Able KW. 2016. Natural history: an approach whose time has come, passed, and needs to be

305   resurrected. *ICES Journal of Marine Science* 73: 2150-2155.

306   Alegre M, Lleonart J, Veny J. 1992. Espècies pesqueres d'interès commercial: nomenclatura

307   official catalana. Barcelona: Departament de Cultura, Generalitat de Catalunya. (In Catalan)

308   Andersson KA. 1942. Fiskar och fiske i Norden. Bd. 1, Fiskar och fiske i havet. Stockholm: Natur

309   och Kultur. (In Swedish)

310   Anonymous. 2017a. Brunsnultra från Måseskär. *Svenskt Fiske* 1:2017: 60. (In Swedish)

311   Anonymous. 2017a. Sportfiskeåret 2016: Saltvattensfiskar. *Svenskt Fiske* 1:2017: 74. (In Swedish)

312   Arlinghaus R, Tillner R, Bork M. 2015. Explaining participation rates in recreational fishing across

313   industrialised countries. *Fisheries Management and Ecology* 22: 45-55.

314   Banha F, Iléhu M, Anastácio PM. 2015. Angling web forums as an additional tool for detection of

315   new fish introductions: the first record of *Perca fluviatilis* in continental Portugal.

316   *Knowledge and Management of Aquatic Ecosystems* 416: 03.

317   Boero F. 2013. Observational articles: a tool to reconstruct ecological history based on chronicling

318   unusual events. *F1000Research* 2: 168.

319   Bradter U, Mair L, Jönsson M, Knape J, Singer A, Snäll T. 2018. Can opportunistically collected

320   Citizen Science data fill a data gap for suitability models of less common species? *Methods*

321   *in Ecology and Evolution*: in press. DOI: 10.1111/2041-21X.13012

322 Brander K., Havenhand J. 2016. Impacts of climate change, including acidification, on marine
323   ecosystems and fisheries. In Reckermann M, Brander K, MacKenzie BR, Omstedt A. (eds.)
324   *Climate Impacts on the Baltic Sea: From Science to Policy*. Berlin Heidelberg: Springer-
325   Verlag, pp. 129-160.

326 Brattegard T. 2001. Endringer i norsk marin bunnfauna 1997-2011. DN-utredning 8-2011.
327   Trondheim: Direktoratet for Naturforvaltning. (In Norwegian).

328 Cedhagen T, Hansson HG. 1995. First records of *Acantholabrus palloni* (Risso, 1810) (Labridae)
329   and *Pomatoschistus norvegicus* (Collett, 1903) (Gobiidae) in the Swedish fish fauna, and a
330   note on the distribution of *Cottunculus microps* Collett, 1875 (Psychrolutidae). *Sarsia* 80:
331   33-34.

332 Craig MT, Pollard D. 2015. *Acantholabrus palloni.* The IUCN Red List of Threatened Species
333   2015: e.T186106A44906675. http://www.iucnredlist.org/, accessed on 12 May 2018.

334 Curry-Lindahl K. 1985. Våra fiskar – havs- och sötvattensfiskar i Norden och övriga Europa.
335   Stockholm: P.A. Norstedts & Söners Förlag. (In Swedish)

336 Debelius H. 1997. *Mediterranean and Atlantic fish guide*. Frankfurt: IKAN – Unterwasserarchiv,
337   305 pp.

338 Devictor V, Whittaker RJ, Beltrame C. 2010. Beyond scarcity: citizen science programmes as
339   useful tools for conservation biogeography. *Diversity and Distributions* 16: 354-362.

340 Dye SR, Hughes SL, Tinker J, Berry DI, Holliday NP, Kent EC, Kennington K, Inall M, Smyth

341   T, Nolan G, Lyons K, Andres O, Beszczynska-Möller A. 2013. Impacts of climate change

342   on temperature (air and sea). *MCCIP Science Review* 2013: 1-12.

343 Economidis PS, Koutrakis E. 2001. Common names of commercially important Hellenic marine

344   organisms. Thessaloniki: Aristotle University.

345 Espeland SH, Nedreaas K, Mortensen S, Skiftesvik AB, Agnalt A-L, Durif C, Harkestad LS,

346   Karlsbakk E, Knutsen H, Thangstad T, Jørstad K, Bjordal Å, Gjøsæter J. 2010.

347   Kunnskapsstatus leppefisk - utfordringer i et økende fiskeri. *Fisken og Havet* 7/2010,

348   Institute of Marine Research, 35 pp. (In Norwegian)

349 Faust E, Halvorsen KT, Andersen P, Knutsen H, André C. 2018. Cleaner fish escape salmon farms

350   and hybridize with local wrasse populations. *Royal Society Open Science* 5: 171752.

351 Fetterplace LC, Turnbull JW, Knott NA, Hardy NA. 2018. The devil in the deep: expanding the

352   known habitat of a rare and protected fish. *European Journal of Ecology* 4: 22-29.

353 Froese R, Pauly D. 2018. FishBase. World Wide Web electronic publication.

354   http://www.fishbase.org/, version 02/2018

355 Granek EF, Madin EMP, Brown MA, Figueira W, Cameron DS, Hogan Z, Kristianson G, de

356   Villiers P, Williams JE, Post J, Zahn S, Arlinghaus R. 2008. Engaging recreational fishers

357   in management and conservation: global case studies. *Conservation Biology* 22: 1125-1134.

358 Hallberg E. 2011. *Assemblages of mobile fauna in the Koster-area: correlative patterns, predictive*

359   *modelling, mapping and possible applications in the planning of a marine national park.*

360   MSc thesis, University of Gothenburg, Sweden, 33 pp.

361   Hanefors B. 1995. Brunsnultra – en ovanlig fångst. *Sportfiske* 12:1995: 73. (In Swedish)

362   Hellenberg N. 2014a. Brunsnultra – en ny art och nytt rekord. *Svenskt Fiske* 4:2014: 65. (In
363   Swedish)

364   Hellenberg N. 2014b. Nytt rekord under rekordåret. *Svenskt Fiske* 5:2014: 64. (In Swedish)

365   Hiddink JG, ter Hofstede R. 2008. Climate induced increases in species richness of marine fishes.
366   *Global Change Biology* 14: 453-460.

367   Holm T, Mattson S. 1980. *Thorogobius ephippiatus* (Pisces) found on the west coast of Sweden.
368   Sarsia 66: 87-88.

369   Hyder K, Weltersbach MS, Armstrong M, Ferter K, Townhill B, Ahvonen A, Arlinghaus R,
370   Baikov A, Bellanger M, Birzaks J, Borch T, Cambie G, de Graaf M, Diogo HMC, Dziemian
371   Ł, Gordoa A, Grzebielec R, Hartill B, Kagervall A, Kapiris K, Karlsson M, Klieven AR,
372   Lejk AM, Levrel H, Lovell S, Lyle J, Moilanen P, Monkman G, Morales-Nin B, Mugerza
373   E, Martinez R, O´Reilly P, Olesen HJ, Papadopoulos A, Pita P, Radford Z, Radtke K, Roche
374   W, Rocklin D, Ruiz J, Scougal C, Silvestri R, Skov C, Steinback S, Sundelöf A, Svagzdys
375   A, Turnbull D, van der Hammen T, van Voorhees D, van Winsen F, Verleye T, Veiga P,
376   Vølstad J-H, Zarauz L, Zolubas T, Strehlow HV. 2018. Recreational sea fishing in Europe
377   in a global context – participation rates, fishing effort, expenditure, and implications for
378   monitoring and assessment. *Fish and Fisheries* 19: 225-243.

379 Kaschner K, Kesner-Reyes K, Garilao C, Rius-Barile J, Rees T, Froese R. 2016. AquaMaps:
380   Predicted range maps for aquatic species. World Wide Web electronic publication,
381   www.aquamaps.org, Version 08/2016.

382 Kesner-Reyes K, Kaschner K, Kullander S, Garilao C, Barile J, Froese R. 2016. AquaMaps:
383   algorithm and data sources for aquatic organisms. In: Froese R & Pauly D (eds). 2016.
384   FishBase. World Wide Web electronic publication. http://www.fishbase.org/, version
385   04/2012

386 Kullander SO. 1999. Swedish fishes: checklist of Swedish fishes. Stockholm: Swedish Museum
387   of Natural History.

388 Kullander SO. 2002. Svenska fiskar: förteckning över svenska fiskar. World Wide Web electronic
389   publication. Stockholm: Swedish Museum of Natural History. (in Swedish)
390   http://www2.nrm.se/ve/pisces/allfish.shtml.se

391 Kullander SO, Nyman L, Jilg K, Delling B. 2012. *Nationalnyckeln till Sveriges flora och fauna.*
392   *Strålfeniga fiskar. Actinopterygii.* Uppsala: ArtDatabanken, 517 pp. (In Swedish)

393 Larsson O, Stevens RL. 2008. Seismic stratigraphy of Late Quaternary deposits in the eastern
394   Skagerrak. *Marine and Petroleum Geology* 25: 1023-1039.

395 Lilljeborg W. 1881. *Labrus palloni* (Risso). Pallonsnultran. In: Lilljeborg W. 1881. *Sveriges och*
396   *Norges fiskar*. Upsala: W. Schultz, pp. 447-452. (In Swedish)

397 Lundgren M, Waje L. 2015. *Havsfiskeboken*. Vallda: Twow! (In Swedish)

398   Machias A, Vassilopoulou V, Vatsos D, Kallianiotis A, Papaconstantinou C, Tsimenides N. 2001.

399   Bottom trawl discards in the northeastern Mediterranean Sea. *Fisheries Research* 53: 181-

400   195.

401   Muus BJ, Nielsen JG, Svedberg U. 1999. *Havsfisk och fiske i Nordvästeuropa*. Stockholm:

402   Bokförlaget Prisma, 337 pp. (In Swedish)

403   Nicolas D, Chaalali A, Drouineau H, Lobry J, Borja A, Boët P. (2011). Impact of global warming

404   on European tidal estuaries: some evidence of northward migration of estuarine fish species.

405   *Regional Environmental Change* 11: 639-649.

406   Nielsen L, Svedberg U. 2006. Våra fiskar. Stockholm: Prisma. (In0 Swedish)

407   Nilsson P. 1997. Biologiska värden i Kosterfjorden – en sammanställning och analys av nuvarande

408   kunskap. *Naturvårdsverket Rapport* 4749, Naturvårdsverket (Swedish Environmental

409   Protection Agency), 75 pp. (In Swedish)

410   Palmkvist J, Scherer A, Liungman A, Rådén R, Mattson M. 2016. Rapport nummer 1: Epibentisk

411   fauna i Västerhavet. In: Länsstyrelserna Västra Götaland, Halland och Skåne län. 2016.

412   *Inventering av marin epibentisk fauna på djupa bottnar*, online publication: Länsstyrelserna

413   Västra   Götaland,   Halland   och   Skåne   län,   pp.   7-142.   Available   at:

414   www.lansstyrelsen.se/vastragotaland (report 2016:30) (In Swedish)

415   Pethon P, Svedberg U. 2004. *Fiskar*, 4th edition. Stockholm: Bokförlaget Prisma, 245 pp. (In

416   Swedish)

417 Pollard D. 2010. *Acantholabrus palloni.* The IUCN Red List of Threatened Species 2010:

418   e.T186106A8501267. http://www.iucnredlist.org/, accessed on 12 May 2018.

419 Rinde E, Hjermann DØ, Staalstrøm A. 2016. Larvae drift simulation of the Pacific oyster in

420   Skagerrak – influence of climate change on larvae development, survival and dispersal.

421   NIVA Report 7016-2016. Oslo: Norwegian Institute for Water Research.

422 Santos RS, Porteiro FM, Barreiros JP. 1997. Marine fishes of the Azores: annotated checklist and

423   bibliography: a catalogue of the Azorean marine ichthyodiversity. Ponta Delgada:

424   Universidade dos Açores.

425 Sartoretto S, Francour P, Harmelin,J-G, Charbonnel É. 1997. Observations *in situ* de deux

426   Labridae profonds, *Lapanella fasciata* et *Acantholabrus palloni*, en Méditerranée nord-

427   occidentale. *Cybium* 21: 37-44. (In French)

428 Sfakiotakis M, Davies JBC, Lane DM. 1999. Review of fish swimming modes for aquatic

429   locomotion. *IEEE Journal of Oceanic Engineering* 24: 237-252.

430 Silvertown J. 2009. A new dawn for citizen science. *Trends in Ecology & Evolution* 24: 467-471.

431 Skov C, Jansen T, Arlinghaus R. 2017. 62 years of population dynamics of European perch (*Perca*

432   *fluviatilis*) in a mesotrophic lake tracked using angler diaries: the role of commercial fishing,

433   predation and temperature. *Fisheries Research* 195: 71-79.

434 SMNH (Swedish Museum of Natural History). 2018. Ichthyology Database: Collection report

435   47556. Available at: http://artedi.nrm.se/nrmfish/ (retieved: 2018-08-17).

436 Stuxberg A. 1894. Sveriges och Norges fiskar. Deras lefnadssätt, födoämnen, lektid, förekomst

437   och utbredning jämte inledning till fiskarnes naturalhistoria. Göteborg: Wettergren &

438   Kerber. (In Swedish)

439 Svansson A. 1975. Physical and chemical oceanography of the Skagerrak and the Kattegatt. I.

440   Open sea conditions. Institute of Marine Research, Report No. 1. Uddevalla: Fishery Board

441   of Sweden/Bohusläningens AB.

442 Swaby SE, Potts GW. 1990. Rare British marine fishes – identification and conservation. *Journal*

443   *of Fish Biology* 37 (supplement A): 133-143.

444 Venturelli PA, Hyder K, Skov C. 2017. Angler apps as a source of recreational fisheries data:

445   opportunities, challenges and proposed standards. *Fish and Fisheries* 18: 578-595.

446 Wirtz P, Brito A, Falcón JM, Freitas R, Fricke R, Monteiro V, Reiner F, Tariche O. 2013. The

447   coastal fishes of the Cape Verde Islands – new records and an annotated check-list. *Spixiana*

448   36: 113-142.

449 Öberg PEW. 1870. *Acantholabrus Couchi* Cuv. Et Val., en för Skandinaviens fauna ny fiskart.

450   *Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar* 1870: 391-395. (In Swedish)

451   FIGURE LEGENDS

452

453   **Figure 1.** Positions for records of *Acantholabrus palloni* in Skagerrak. Red dots represent non-

454   angling records, showing the previously documented occurrence, and blue dots represent angling

455   records reported in this paper. Red arrows show the large-scale current patterns in the area, and

456   dotted lines delineate approximate 40- and 80-m depth curves. A: Hidra Island, Norway, first

457   Scandinavian record (Öberg 1870); B: Singlefjord mouth, Sweden, first Swedish record (identical

458   to position 5) (Cedhagen & Hansson 1995); 1: S. Langesund city, Norway; 2: Ferder Lighthouse,

459   Oslofjord, Norway; 3: S. Missingen Islands, Oslofjord, Norway; 4: Koster Fjord area, Sweden; 5:

460   Singlefjord mouth, Sweden; 6: W. Stora Pölsan lighthouse, Sweden; 7: Persgrunden, Sweden; 8:

461   Grisbådarna, Sweden; 9: Kullarna (S.W. Måseskär lighthouse), Sweden; 10: N.W. Hunnebostrand

462   city, Sweden; 11: Gullmarn Fjord, Sweden; 12: Svaberget, Sweden; 13: Väderöarna (Weather

463   Islands), Sweden; 14: W. Ursholmen Island. Names of areas of angling grounds (pos. 7-9, and 12)

464   are based on Lundgren & Waje (2015); currents and depth curves are drawn after Svansson (1975)

465   and Larsson and Stevens (2008).

466

467   **Figure 2.** Pictures of *Acantholabrus palloni* from Swedish waters (Position 9 in Fig. 1). (A)

468   Record #8, Table 1; (B) Record #9, Table 1. Published with permission (Photo credit: M.

469   Lundgren).

Records of *A. palloni* in Swedish waters.

L = Total length, M = wet mass.

1 **Table 1.** Records of *A. palloni* in Swedish waters. L = Total length, M = wet mass.

Record number	Date	Size	Capture method	Location (Fig 1)	Notes	Information source
1	1993	Juvenile	Dredge haul	Pos 5	First record from Swedish waters, first inshore record	Cedhagen & Hansson 1995
2	1995-07	L: 23 cm M: 142 g	Angling	Pos 8		Hanefors 1995
3	2007-07-09	L: No record M: 265 g	Angling	Pos 7	Verified by M. Lundgren	Records of Kungsbacka Angling Club
4	2007-11-16	L: No record M: No record	Filmed, Remotely Operated Vehicle	Pos 7	50 m depth. Reported by A. Tullot (record #61250199). Unverified.	https://artportalen.se/
5	2008	L: No record M: No record	Unknown	Pos 6	Verified by S.O. Kullander, Swedish Museum of Natural History in GBIF	http://www.gbif.se/
6	No info. (Pre-2011)	L: No record M: No record	Filmed, Remotely Operated Vehicle	Pos 4		Hallberg 2011
7	2010	L: No record M: No record	Angling	Pos 9	Verified by M. Lundgren, direct observation	M. Durell, pers. comm.
8	2011-06-04	L: No record M: 220 g	Angling	Pos 9	Figure 2.	M. Lundgren, pers. obs.
9	2011-06-05	L: No record M: 180 g	Angling	Pos 9	Figure 2.	M. Lundgren, pers. obs.

10	2011-06-05	L: No record M: 160-180 g (estimated)	Angling	Pos 9		M. Lundgren, pers. obs.
11	2012-05-26	L: No record M: 120 g	Angling	Pos 9		http://www.sg-zander.se/
12	2014-06-01	L: 26 cm M: 275 g	Angling	Pos 9	12.5 m depth[1], rocky bottom	http://www.sportfiskarna.se/, Hellenberg 2014a,b
13	2014-07-26	L: 26 cm M: 260 g	Angling	Pos 10	44 m depth, rocky bottom	http://www.sportfiskarna.se/, Hellenberg 2014b
14	2014-08-16	L: 26 cm M: 250 g	Angling	Pos 10	47 m depth, rocky bottom	http://www.sportfiskarna.se/, Hellenberg 2014b
15	2014-08-16	L: 27.5 cm M: 282 g	Angling	Pos 10	46 m depth, rocky bottom	http://www.sportfiskarna.se/, Hellenberg 2014b
16	2015-07-13	L: No record M: 200 g	Angling	Pos 11	First record from the fjord Gullmarn, second inshore record from Swedish waters. Verified by M. Lundgren, direct observation	M. Jonsson, pers. comm.
17	2015-07-17	L: 29 cm M: 296 g	Angling	Pos 12	26 m depth, rocky bottom	http://www.sportfiskarna.se/
18	2015-08-06	L: 28 cm M: 293 g	Angling	Pos 10	50 m depth, rocky bottom	http://www.sportfiskarna.se/
19	2015-08-06	L: 28 cm M: 285 g	Angling	Pos 10	50 m depth, rocky bottom	http://www.sportfiskarna.se/
20	2015-08-06	L: 27 cm M: 267 g	Angling	Pos 10	50 m depth, rocky bottom	http://www.sportfiskarna.se/

21	2015-08-09	L: 27.5 cm M: 260 g	Angling	Pos 13	35 m depth, rocky bottom	http://www.sportfiskarna.se/
22	2015-08-20	L: 26.5 cm M: 260 g	Angling	Pos 9	42 m depth, rocky bottom	http://www.sportfiskarna.se/
23	2015-08-20	L: 26 cm M: 250 g	Angling	Pos 9	41 m depth, rocky bottom	http://www.sportfiskarna.se/
24	2015-08-21	L: 27 cm M: 260 g	Angling	Pos 13	32 m depth, rocky bottom	http://www.sportfiskarna.se/
25	2015-08-22	L: 27 cm M: 280 g	Angling	Pos 10	40 m depth	http://www.sportfiskarna.se/
26	2015-08-22	L: 27.5 cm M: 267 g	Angling	Pos 10	38 m depth, rocky bottom	http://www.sportfiskarna.se/
27	2015-08-22	L: 28 cm M: 270 g	Angling	Pos 10	40 m depth, rocky bottom	http://www.sportfiskarna.se/
28	2015-08-22	L: 28.5 cm M: 300 g	Angling	Pos 10	45 m depth, rocky bottom	http://www.sportfiskarna.se/
29	2015-08/09	L: No record M: No record	Filmed, Remotely Operated Vehicle	Pos 6	30-35 m depth, rocky bottom	Palmkvist et al. 2016
30	2015-10-04	L: 27 cm M: 270 g	Angling	Pos 6	28 m depth, rocky bottom	http://www.sportfiskarna.se/
31	2016-07-24	L: 26 cm M: 260 g	Angling	Pos 8	37 m depth, rocky bottom Verified from photograph by J. Näslund	A. Enemar, pers. comm.

32-37	2016-09	L: No record M: 70-200 g	Angling	Pos 14	5 individuals. 35-50 m depth, rocky bottom	A. Enemar, pers. comm.
38	2016-08-19	L: 28.5 cm M: 320 g	Angling	Pos 9	42 m depth, rocky bottom	http://www.sportfiskarna.se/ Anonymous 2017a
39	2016-08-25	L: 26.5 cm M: 270 g	Angling	Pos 12	41 m depth, rocky bottom	http://www.sportfiskarna.se/ Anonymous 2017b

[1.] Possibly an error in the report of depth

Figure 1

Positions for records of *Acantholabrus palloni* in Skagerrak.

Red dots represent non-angling records, showing the previously documented occurrence, and blue dots represent angling records reported in this paper. Red arrows show the large-scale current patterns in the area, and dotted lines delineate approximate 40- and 80-m depth curves. A: Hidra Island, Norway, first Scandinavian record (Öberg 1870); B: Singlefjord mouth, Sweden, first Swedish record (identical to position 5) (Cedhagen & Hansson 1995); 1: S. Langesund city, Norway; 2: Ferder Lighthouse, Oslofjord, Norway; 3: S. Missingen Islands, Oslofjord, Norway; 4: Koster Fjord area, Sweden; 5: Singlefjord mouth, Sweden; 6: W. Stora Pölsan lighthouse, Sweden; 7: Persgrunden, Sweden; 8: Grisbådarna, Sweden; 9: Kullarna (S.W. Måseskär lighthouse), Sweden; 10: N.W. Hunnebostrand city, Sweden; 11: Gullmarn Fjord, Sweden; 12: Svaberget, Sweden; 13: Väderöarna (Weather Islands), Sweden; 14: W. Ursholmen Island. Names of areas of angling grounds (pos. 7-9, and 12) are based on Lundgren & Waje (2015); currents and depth curves are drawn after Svansson (1975) and Larsson and Stevens (2008).
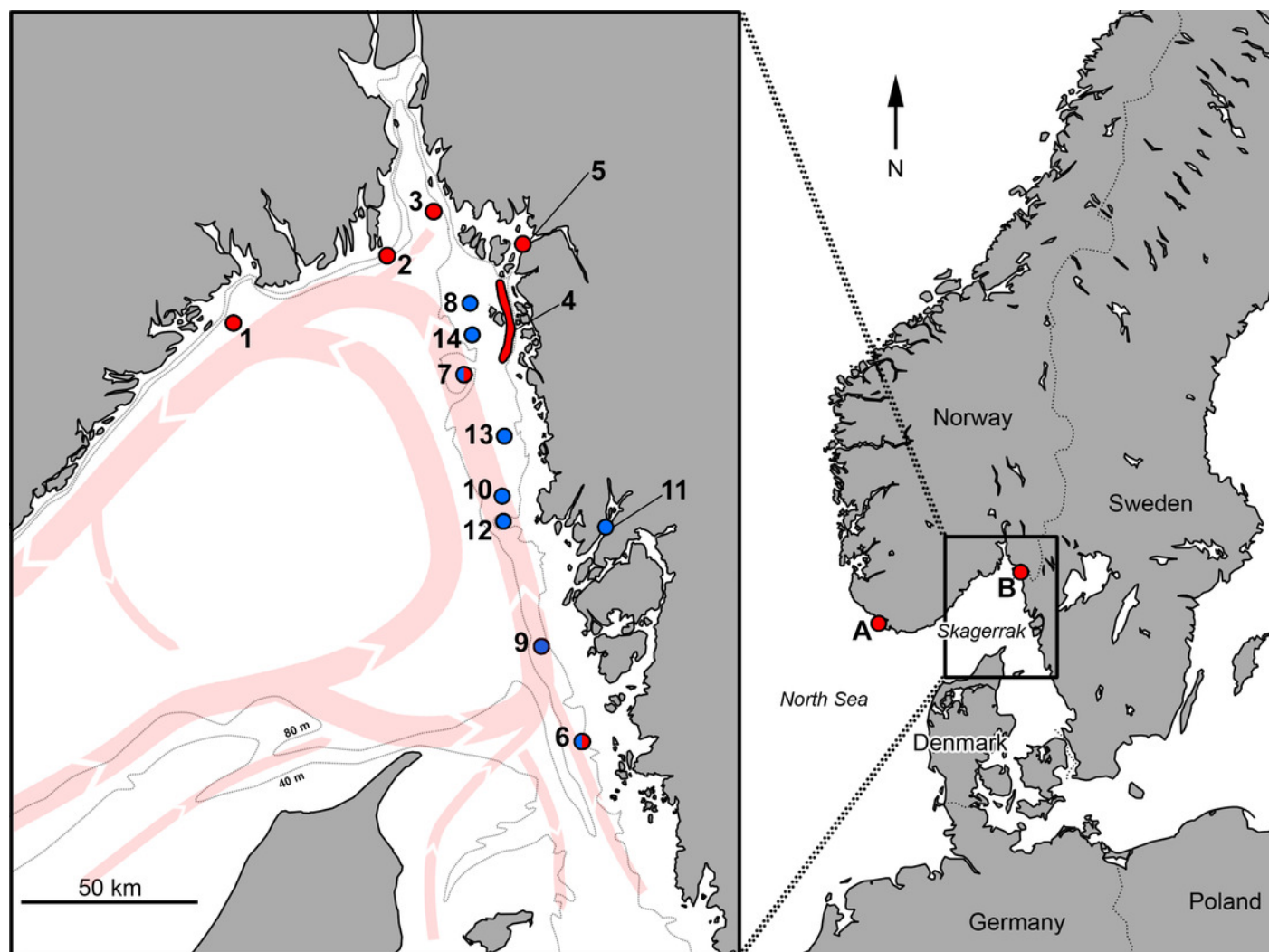
Figure 2

Pictures of Acantholabrus palloni from Swedish waters (Position 9 in Fig. 1).

(A) Record #8, Table 1; (B) Record #9, Table 1. Published with permission (Photo credit: M. Lundgren).