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

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In this paper, we tentatively map the distribution of scale-rayed wrasse *Acantholabrus palloni* in eastern Skagerrak based on a combination of verified and privately 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.

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ABSTRACT

In this paper, we tentatively map the distribution of scale-rayed wrasse *Acantholabrus palloni* in eastern Skagerrak based on a combination of verified and privately 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.

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 indiscriminant 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 taxonomy, as well as species ecology and distribution, exist not only for birds, but also for fishes in the form of 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

& Waje 2015) Hence, anglers' records and notes are excellent sources for confirmatory qualitative data on presence of species in certain areas and can be a useful and important, but underutilized, auxiliary source for mapping distributions of data-deficient species. In this paper, the aim is to present a desktop study where citizen-generated data, in the form of private and publicly available angling records, are used to map out a tentative distribution map for a data-deficient species, the scale-rayed wrasse *Acantholabrus palloni* (Risso, 1810), in Swedish waters.

Acantholabrus palloni is a labrid fish inhabiting the eastern Atlantic Ocean and the Mediterranean Sea, with a known latitudinal range from Gabon in western Africa to mid- Norway, including areas around some of the eastern Atlantic offshore islands, like Madeira and the Canary Islands (Debelius, 1997; Muus, Nielsen & Svedberg, 1999; Pollard, 2010; Kullander et al. 2012). The full range of the species is continuously being mapped out, with relatively recent documented records from e.g. the Azores and Cape Verde Islands (Santos, Porteiro & Barreiros, 1997; Wirtz et al. 2013). The species is considered rare throughout its known range, but since its typical habitat (coralline and rocky offshore reefs) are seldom trawled, its population may be underestimated due to lack of capture records (Swaby & Potts 1990; Pollard 2010). Little is known about its ecology; it is considered to live solitarily or in small groups, and the diet mainly consists of benthic invertebrates (Pollard 2010). It is light brown in colour and characterized by one black blotch on the posterior part of the dorsal fin, a black blotch on the dorsal part of the trunk and several lighter blotches on the back, below the dorsal fin. By these characteristics, the species is well distinguished from other wrasse species in Swedish waters. In the Mediterranean Sea it is often found on rocky bottoms at depths below 80 m (Sartoretto *et al*. 1997). In the northern parts of its range, however, it has been found at shallower depth (from 18 m; Debelius, 1997; Kullander *et al*., 2012). In Norway, the species has been considered rare, but recent evidence suggest that there are larger

concentrations of the species in e.g. the Hardangerfjord, and anecdotal reports from scuba-divers suggest it is more common than previously thought (Espeland *et al*., 2010). The species is regularly captured by anglers in the Norwegian part of northern Skagerrak, just south of Langesund, on rocky bottoms at 40 to 60 m depth, elevating from deeper soft bottoms (Fig. 1., position 1; M. Lundgren, personal observations; also documented in the catch-records of the Langesund Seafood and Fishing Festival; http://www.lsff.no/; data accessed 2014-04-23). Three preserved specimens from Norwegian parts of the eastern Skagerrak (captured in 1966, 1968 and 1985), around the southern parts of the Oslofjord area (Fig. 1., one specimen at position 2, and two specimens at position 3), are also available at the Natural History Museum, University of Oslo, according to the Global Biodiversity Information Facility (GBIF) database (https://www.gbif.org/). The eastern limits in the Skagerrak are however not well established for *A. palloni.* On the one hand, the species has been noted as not being native to Swedish waters (Pethon & Svedberg, 2004; Pollard, 2010; Craig & Pollard 2015), or alternatively, only being present in the Koster Fjord area (Nilsson, 1997; Fig. 1, position 4). On the other hand, the FishBase database (http://www.fishbase.org/; Froese & Pauly 2018) lists the species as native, based on the Swedish checklist of fishes (Kullander 1999); this checklist, however, lists all species recorded in Swedish waters, including sporadic visitors. In an updated checklist, the occurrence of *A. palloni* is noted as "sporadic" (Kullander 2002). The FishBase-associated AquaMaps project (http://www.aquamaps.org/; Kaschner *et al*., 2016) has a predicted occurrence probability of 0.60-0.79 in Swedish waters (Kesner-Reyes *et al*., 2016), based on a single verified and a few unverified records in GBIF (the single verified record, from southern Skagerrak, is noted here in the Results section). Recently, the distribution of the species has been suggested to be wider than previously thought in Swedish waters, based on multiple reports of angled specimens.

MATERIALS AND METHODS

Swedish non-angling records (1993-2016)

Non-angling records were sourced from the scientific literature (Cedhagen & Hansson 1995; Hallberg 2011), the Swedish Species Observation System (SSOS; http://www.artportalen.se/), and the GBIF-Sweden Data Portal (http://www.gbif.se/).

Swedish angling records (1995-2016)

The majority of the angling records were obtained from the curated specimen registry (*Storfiskregistret*) of the Swedish Anglers Association (SAA; http://www.sportfiskarna.se/), where anglers can report catches of fish specimens above a certain species-specific mass-limit, which then gets validated based on photographs, accessory information, and, if needed, expert assessment. The SAA records contains additional information about capture location, depth, habitat, and capture method. The mass-limit for recording an *A. palloni* in the SAA specimen registry is 250 g (effective since 2012; before that it was 300 g, but no registered records exist from this time-period).

Additional records, were supplied by Swedish anglers, located through posts on internet blogs or through personal communication. A number of records are also direct personal observations by the authors (e.g. specimens in Figure 2). Furthermore, some records in the SAA registry had less than ideal specificity regarding the exact capture location. In such cases, the angler was contacted for further information.

All records from the SAA database in Table 1 have been verified by the authors from photographs. SAA carries digital copies of all fish in their records. Personal communications were obtained

from experienced sea anglers; some of these records are unverified (see Table 1) and should therefore be used mainly as auxiliary information. While misidentification of the species is possible, specimen sea anglers are typically examining their catch closely when resembling a rare species. Hence, the unverified angling records are judged to be highly likely to be valid.

124 RESULTS

125 *Swedish non-angling records*

126 The occurrence of *A. palloni* in Swedish waters is rarely reported prior to 2010, with a first record
127 of a juvenile specimen from year 1993 from somewhere between 50 and 115 m depth in the mouth
128 of the Singlefjord, northeastern Skagerrak (Cedhagen & Hansson, 1995; Fig. 1., position 5). The
129 species has also been previously reported from the Koster Fjord area around the Koster Islands,
130 northeastern Skagerrak, (Fig. 1, position 4; Hallberg, 2011) and 6 km west of Rörö Island (Fig 1.,
131 position 6), southern Skagerrak in 2008 (data provided by Swedish Museum of Natural History,
132 Stockholm; accessed through GBIF-Sweden Data Portal, 2014-04-25). Only two unverified
133 observations were found in SSOS (as of 2018-05-22). The first record comes from Persgrunden
134 (Fig. 1, position 7), stemming from a scientific transect investigation using a remotely operated
135 vehicle in 2007; the second is a questionable record from the harbor of Käringön. The latter record
136 (record 54966014 in SSOS) is not reported in Table 1, due to the species not being a typical species
137 seen in the shallow waters in harbors [in contrast to the similar looking goldsinny wrasse
138 *Ctenolabrus rupestris* (Linnaeus 1758)].

139

140 *Angling records*

141 Between the first Swedish record in 1993 (Cedhagen & Hansson 1995) and 2011, a few angling
142 records of *A. palloni* were noted from different sites on the Swedish west coast (Table 1). Between
143 2011 and 2016, several records of *A. palloni* have been provided by leisure anglers (Table 1).
144 Repeated captures of the species have been made across years, at least at a few positions (e.g.
145 position 9; Table 1).

Most angled specimens are reported to be caught on, or directly above, rocky bottom at depths of 28-50 m. Another specimen standing out from the rest is record #16 which is the only one caught inshore (in the Gullmarn Fjord, Fig 1, Position 11), apart from the first Swedish record by Cedhagen & Hansson (1995).

DISCUSSION

The presented records extend the knowledge about the marine ichthyofauna of eastern Skagerrak, which is a generally well documented area regarding fish species distributions (Kullander *et al*., 2012).

The records of *A. palloni* presented here are, to the authors' knowledge, the first documentation of several individuals of this species being repeatedly caught in the same general location in Swedish waters, outside of the Koster Fjord area, in the scientific literature. It should be noted that number of angled specimens at any given position are likely related to the specific fishing pressure at that site, and data are limited to adult specimens as a consequence of the size-restrictions in the SSA database (see Materials and Methods). Still, these repeated captures across several years indicate that *A. palloni* could be established in, at least some, areas of eastern Skagerrak. Hence, it should no longer be considered only an occasional visitor. Speculatively, the recent surge in records could be an indication of a range extension, perhaps due to changing climate as has been indicated in other places in European marine waters, including the North Sea which is adjacent to Skagerrak (Hiddink and ter Hofstede, 2008; Nicolas *et al*., 2011). Even though the angling records are located south of the northern range limit, the eastern Skagerrak is still at the edge of the population distribution. Hence, a climate-related population increase at the northern distribution range may cause spillover effects southwards into the Swedish national waters of Skagerrak. However, general lack of appropriate historical data makes it impossible to determine whether this is the case or not. It is also impossible to distinguish climate effects from other effects such as fishing or meta-population dynamics (Brander and Havenhand, 2016). The three specimens captured in the Oslofjord area between 1966 and 1984 provide a weak indication that the species may have just been an overlooked rare, but native, species in eastern Skagerrak.

The angled specimens are all captured between May and October, which represents the time when the angling activity is highest. Therefore, we still cannot exclude that the species is a seasonally migratory species in this geographic area. An additional unverified underwater observation was made in November during a scientific expedition at Persgrunden (record #4; Table 1); but November-temperatures at >25 m depth largely matches spring- to early-summer temperatures (Svansson 1975), so such an observation does not indicate a non-migratory behaviour. However, given the apparent strong reef-association, the small body size, and the labriform swimming mode, which is relatively inefficient for long-distance swimming (Sfakiotakis, Davies & Lane, 1999), a seasonal migratory life-style seems unlikely. Notably, Craig and Pollard (2015) states that it is not a migratory species; however, without explicit support from data or references. It is also possible that Skagerrak acts as a sink for the *A. palloni* population, with young individuals drifting into the Skagerrak area from the North Sea and then settling on suitable rocky reefs. Currents from the North Sea bring higher-salinity water into the southern Skagerrak, which thereafter mainly follows the Swedish coast northwards in a counter-clockwise fashion (Svansson 1975). This current pattern, along with the depth interval of 40-80 m, largely matches the Swedish distribution of *A. palloni* as currently described. However, until spawning and viable fry can be demonstrated from Skagerrak, it is not possible to know whether the Skagerrak population is self-reproducing. Systematic investigations of angled specimens (e.g. in association with marine angling competitions) could provide information about spawning activity, as well as feeding habits and parasite fauna – all of which are largely unknown for the species (Kullander *et al*., 2012). Studies on population genetics may provide further insights into the population structure of the species (see e.g. Faust *et al*., 2018). Hence, such investigations could be encouraged to extend the knowledge of this data-deficient species.

The present study shows that *A. palloni* is generally captured over off-shore rocky reefs. Smaller-sized marine fish species, such as *A. palloni*, have historically not been targeted by off-shore anglers to the same extent they currently are (Lundgren & Waje, 2015). While coastal anglers use a wide variety of hook-sizes, off-shore anglers have, until recently, mainly used larger hooks targeting larger species. With the relatively small gape-size of *A. palloni*, this may effectively have eliminated the species from being caught, even though the capture sites reported here have been commonly targeted reefs for angling (Lundgren & Waje, 2015). In addition, the typical rocky reef habitat is likely seldom trawled by commercial fishermen, probably leading to few specimens being caught in fisheries overall (Pollard, 2010). While clearly distinguished at closer inspection (which is typically what specimen sea anglers do), it also resembles the common goldsinny wrasse and young female cuckoo wrasse *Labrus mixtus* Linnaeus 1758 in coloration, which may lead to misidentification and oversight by e.g. fishermen not interested in the species for commercial purposes. These facts may have limited the number of captures and historical reports from Swedish waters.

Despite its relatively small size, *A. palloni* has value for marine specimen angling, e.g. in marine angling competitions where the number of species caught is rewarded. In fact, the angling records being presented in this article are largely a consequence of this species being acknowledged as a target for specimen anglers, who are specifically targeting large specimens of different species (e.g. Hellenberg, 2014a,b; Lundgren & Waje, 2015). In commercial fisheries, however, it has generally little value (Machias *et al*., 2001), although it has been noted among the targeted species in some Mediterranean countries (e.g. Alegre, Lleonart & Veny, 1992; Economidis & Koutrakis 2001). Smaller wrasse species are fished commercially in Scandinavia for sea lice control in salmon farms (Espeland *et al*., 2010), but *A. palloni* is not suited for such fishery as it is deeper-

220 living than most of the other smaller wrasses (e.g. corkwing wrasse *Symphodus melops* and
221 juvenile ballan wrasse *Labrus bergylta*) and, thus, generally subjected to severe barotrauma when
222 hauled, resulting in inflated swim-bladders and bulging eye-balls (see e.g. Fig. 2).

223 This study presents a case where citizen generated data can be used for increasing the knowledge
224 about a rare species. It is possible that recognition of the angler community as a valuable source
225 of information may increase anglers' interest in continuing and increasing the frequency and detail
226 of their reports. Anglers are often keen to participate in the management of fish stocks, and this
227 type of recognition may lead to a further increased interest in fish conservation issues (Granek et
228 al. 2008). From a conservation and management perspective, the current data provides a coarse
229 picture of the distribution, and data reliable enough to make e.g. quantitative habitat suitability
230 models (HSM), as has been done for some bird species based on citizen observations (Bradter et
231 al. 2018), is hard to come by, mainly due to the scarcity of data about habitat conditions at capture
232 sites. Bradter et al. (2018) constructed HSMs for Siberian Jays in Sweden, utilizing data from the
233 SSOS. As compared to e.g. birds, for which the SSOS reporting system is run in collaboration with
234 BirdLife Sweden (the Swedish Ornithological Society), fish appear to be under-reported in SSOS.
235 Hence, the SAA database appears to be substantially more informative and reliable for
236 observational reports of fish at the present point in time, despite having a lower mass-limits for
237 reports, which limits the number of reports in general and completely eliminates reports of juvenile
238 specimens.

239 Finally, it is worth noting that the current list of records (Table 1) is not a complete record of
240 angled *A. palloni*, as several other specimens (typically smaller ones) have been verbally described
241 to the authors by anglers, without any specific information being noted by the angler.

CONCLUSIONS

In this article, we summarize the present knowledge about the current distribution of *A. palloni* in Swedish waters, at the edge of the distribution range of the species. The records of *A. palloni* presented here in particular highlight the importance of citizen-generated data in the form of anglers' reports and angling records as useful contributions for ichthyological investigations of presence and distribution of non-commercial fish species.

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ETHICAL APPROVAL

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

SAMPLING AND FIELD STUDIES

Fish specimens reported were caught following Swedish or Norwegian angling regulations. All cases where the authors captured recorded specimens were part of non-scientific angling expeditions, conducted prior to the conception of the study.

260 REFERENCES

261 Able KW. 2016. Natural history: an approach whose time has come, passed, and needs to be
262 resurrected. *ICES Journal of Marine Science* 73: 2150-2155.

263 Alegre M, Lleonart J, Veny J. 1992. Espècies pesqueres d'interès commercial: nomenclatura
264 official catalana. Barcelona: Departament de Cultura, Generalitat de Catalunya. (In Catalan)

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

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

267 Arlinghaus R, Tillner R, Bork M. 2015. Explaining participation rates in recreational fishing across
268 industrialised countries. *Fisheries Management and Ecology* 22: 45-55.

269 Banha F, Iléhu M, Anastácio PM. 2015. Angling web forums as an additional tool for detection of
270 new fish introductions: the first record of *Perca fluviatilis* in continental Portugal.
271 *Knowledge and Management of Aquatic Ecosystems* 416: 03.

272 Boero F. 2013. Observational articles: a tool to reconstruct ecological history based on chronicling
273 unusual events. *F1000Research* 2: 168.

274 Bradter U, Mair L, Jönsson M, Knape J, Singer A, Snäll T. 2018. Can opportunistically collected
275 Citizen Science data fill a data gap for suitability models of less common species? *Methods*
276 *in Ecology and Evolution*: in press. DOI: 10.1111/2041-21X.13012

277 Brander K., Havenhand J. 2016. Impacts of climate change, including acidification, on marine
278 ecosystems and fisheries. In Reckermann M, Brander K, MacKenzie BR, Omstedt A. (eds.)

279 *Climate Impacts on the Baltic Sea: From Science to Policy*. Berlin Heidelberg: Springer-
280 Verlag, pp. 129-160.

281 Cedhagen T, Hansson HG. 1995. First records of *Acantholabrus palloni* (Risso, 1810) (Labridae)
282 and *Pomatoschistus norvegicus* (Collett, 1903) (Gobiidae) in the Swedish fish fauna, and a
283 note on the distribution of *Cottunculus microps* Collett, 1875 (Psychrolutidae). *Sarsia* 80:
284 33-34.

285 Craig MT, Pollard D. 2015. *Acantholabrus palloni.* The IUCN Red List of Threatened Species
286 2015: e.T186106A44906675. http://www.iucnredlist.org/, accessed on 12 May 2018.

287 Debelius H. 1997. *Mediterranean and Atlantic fish guide*. Frankfurt: IKAN – Unterwasserarchiv,
288 305 pp.

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

291 Economidis PS, Koutrakis E. 2001. Common names of commercially important Hellenic marine
292 organisms. Thessaloniki: Aristotle University.

293 Espeland SH, Nedreaas K, Mortensen S, Skiftesvik AB, Agnalt A-L, Durif C, Harkestad LS,
294 Karlsbakk E, Knutsen H, Thangstad T, Jørstad K, Bjordal Å, Gjøsæter J. 2010.
295 Kunnskapsstatus leppefisk - utfordringer i et økende fiskeri. *Fisken og Havet* 7/2010,
296 Institute of Marine Research, 35 pp. (In Norwegian)

297 Faust E, Halvorsen KT, Andersen P, Knutsen H, André C. 2018. Cleaner fish escape salmon farms
298 and hybridize with local wrasse populations. *Royal Society Open Science* 5: 171752.

299 Froese R, Pauly D. 2018. FishBase. World Wide Web electronic publication.
300 http://www.fishbase.org/, version 02/2018

301 Granek EF, Madin EMP, Brown MA, Figueira W, Cameron DS, Hogan Z, Kristianson G, de
302 Villiers P, Williams JE, Post J, Zahn S, Arlinghaus R. 2008. Engaging recreational fishers
303 in management and conservation: global case studies. *Conservation Biology* 22: 1125-1134.

304 Hallberg E. 2011. *Assemblages of mobile fauna in the Koster-area: correlative patterns, predictive*
305 *modelling, mapping and possible applications in the planning of a marine national park.*
306 MSc thesis, University of Gothenburg, Sweden, 33 pp.

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

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

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

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

313 Hyder K, Weltersbach MS, Armstrong M, Ferter K, Townhill B, Ahvonen A, Arlinghaus R,
314 Baikov A, Bellanger M, Birzaks J, Borch T, Cambie G, de Graaf M, Diogo HMC, Dziemian
315 Ł, Gordoa A, Grzebielec R, Hartill B, Kagervall A, Kapiris K, Karlsson M, Klieven AR,
316 Lejk AM, Levrel H, Lovell S, Lyle J, Moilanen P, Monkman G, Morales-Nin B, Mugerza
317 E, Martinez R, O´Reilly P, Olesen HJ, Papadopoulos A, Pita P, Radford Z, Radtke K, Roche
318 W, Rocklin D, Ruiz J, Scougal C, Silvestri R, Skov C, Steinback S, Sundelöf A, Svagzdys

A, Turnbull D, van der Hammen T, van Voorhees D, van Winsen F, Verleye T, Veiga P, Vølstad J-H, Zarauz L, Zolubas T, Strehlow HV. 2018. Recreational sea fishing in Europe in a global context – participation rates, fishing effort, expenditure, and implications for monitoring and assessment. *Fish and Fisheries* 19: 225-243.

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

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

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

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

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

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

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

340 Machias A, Vassilopoulou V, Vatsos D, Kallianiotis A, Papaconstantinou C, Tsimenides N. 2001.
341 Bottom trawl discards in the northeastern Mediterranean Sea. *Fisheries Research* 53: 181-
342 195.

343 Muus BJ, Nielsen JG, Svedberg U. 1999. *Havsfisk och fiske i Nordvästeuropa*. Stockholm:
344 Bokförlaget Prisma, 337 pp. (In Swedish)

345 Nicolas, D., Chaalali, A., Drouineau, H., Lobry, J., Borja, A. and Boët, P. (2011). Impact of global
346 warming on European tidal estuaries: some evidence of northward migration of estuarine
347 fish species. *Regional Environmental Change* 11: 639-649.

348 Nilsson P. 1997. Biologiska värden i Kosterfjorden – en sammanställning och analys av nuvarande
349 kunskap. *Naturvårdsverket Rapport* 4749, Naturvårdsverket (Swedish Environmental
350 Protection Agency), 75 pp. (In Swedish)

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

353 Pollard D. 2010. *Acantholabrus palloni.* The IUCN Red List of Threatened Species 2010:
354 e.T186106A8501267. http://www.iucnredlist.org/, accessed on 12 May 2018.

355 Santos RS, Porteiro FM, Barreiros JP. 1997. Marine fishes of the Azores: annotated checklist and
356 bibliography: a catalogue of the Azorean marine ichthyodiversity. Ponta Delgada:
357 Universidade dos Açores.

Sartoretto S, Francour P, Harmelin,J-G, Charbonnel É. 1997. Observations *in situ* de deux Labridae profonds, *Lapanella fasciata* et *Acantholabrus palloni*, en Méditerranée nord-occidentale. *Cybium* 21: 37-44. (In French)

Sfakiotakis M, Davies JBC, Lane DM. 1999. Review of fish swimming modes for aquatic locomotion. *IEEE Journal of Oceanic Engineering* 24: 237-252.

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

Skov C, Jansen T, Arlinghaus R. 2017. 62 years of population dynamics of European perch (*Perca fluviatilis*) in a mesotrophic lake tracked using angler diaries: the role of commercial fishing, predation and temperature. *Fisheries Research* 195: 71-79.

Svansson A. 1975. Physical and chemical oceanography of the Skagerrak and the Kattegatt. I. Open sea conditions. Institute of Marine Research, Report No. 1. Uddevalla: Fishery Board of Sweden/Bohusläningens AB.

Swaby SE, Potts GW. 1990. Rare British marine fishes – identification and conservation. *Journal of Fish Biology* 37 (supplement A): 133-143.

Venturelli PA, Hyder K, Skov C. 2017. Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. *Fish and Fisheries* 18: 578-595.

Wirtz P, Brito A, Falcón JM, Freitas R, Fricke R, Monteiro V, Reiner F, Tariche O. 2013. The coastal fishes of the Cape Verde Islands – new records and an annotated check-list. *Spixiana* 36: 113-142.

377 FIGURE LEGENDS

378

379 **Figure 1.** Positions for records of *Acantholabrus palloni* in Skagerrak. Red dots represent non-
380 angling records, showing the previously documented occurrence, and blue dots represent angling
381 records reported in this paper. Red arrows show the large-scale current patterns in the area, and
382 dotted lines delineate approximate 40- and 80-m depth curves. 1: S. Langesund city, Norway; 2:
383 Ferder Lighthouse, Oslofjord, Norway; 3: S. Missingen Islands, Oslofjord, Norway; 4: Koster
384 Fjord area, Sweden; 5: Singlefjord mouth, Sweden; 6: W. Stora Pölsan lighthouse, Sweden; 7:
385 Persgrunden, Sweden; 8: Grisbådarna, Sweden; 9: Kullarna (S.W. Måseskär lighthouse), Sweden;
386 10: N.W. Hunnebostrand city, Sweden; 11: Gullmarn Fjord, Sweden; 12: Svaberget, Sweden; 13:
387 Väderöarna (Weather Islands), Sweden; 14: W. Ursholmen Island. Names of areas of angling
388 grounds (pos. 7-9, and 12) are based on Lundgren & Waje (2015); currents and depth curves are
389 drawn after Svansson (1975) and Larsson and Stevens (2008).

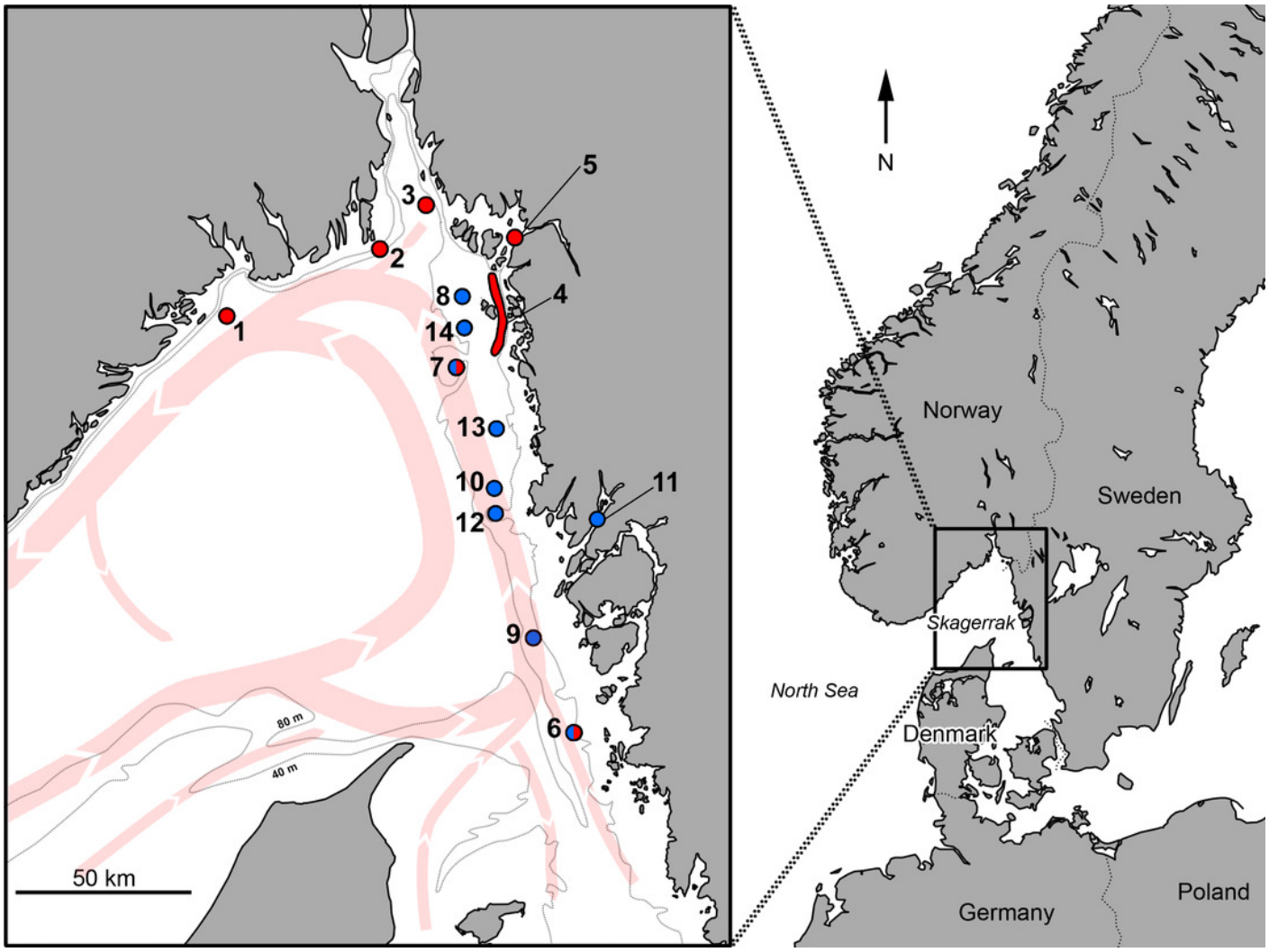
390

391 **Figure 2.** Pictures of *Acantholabrus palloni* from Swedish waters (Position 9 in Fig. 1). (A)
392 Record #8, Table 1; (B) Record #9, Table 1. Published with permission (Photo credit: M.
393 Lundgren).

Figure 1

Distribution map.

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. 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).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13
14
80 m
40 m
50 km
N
Norway
Sweden
Skagerrak
North Sea
Denmark
Germany
Poland

Figure 2

Examples of angled specimens of scale-rayed wrasse.

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).

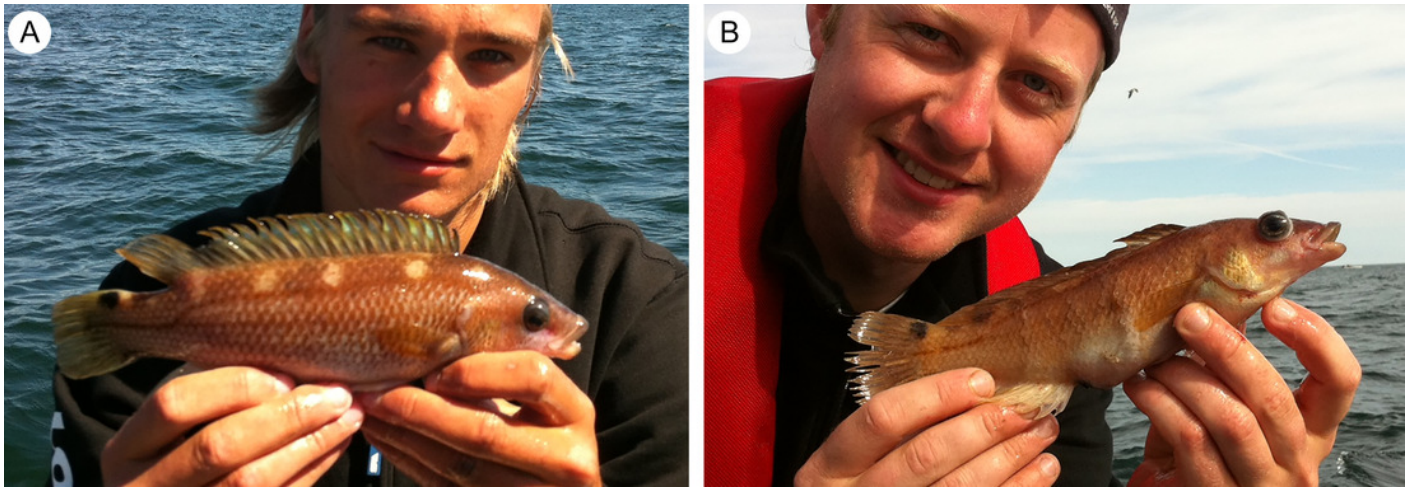

Table 1(on next page)

Swedish scale-rayed wrasse specimens

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	2015-10-04	L: 27 cm M: 270 g	Angling	Pos 6	28 m depth, rocky bottom	http://www.sportfiskarna.se/
30	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.
31-36	2016-09	L: No record M: 70-200 g	Angling	Pos 14	5 individuals. 35-50 m depth, rocky bottom	A. Enemar, pers. comm.
37	2016-08-19	L: 28.5 cm M: 320 g	Angling	Pos 9	42 m depth, rocky bottom	http://www.sportfiskarna.se/ Anonymous 2017a

38	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

2