Received: 9 May 2025 | Revised: 28 May 2026 | Accepted: 2 June 2026

DOI: 10.1111/jfb.70531

JOURNAL OF FISH BIOLOGY fsbi

BRIEF COMMUNICATION

Modified fin morphology in mackerel icefish (*Champsocephalus gunnari*) may indicate nesting behaviour

Huw W. James[1,2] | Fabrice Stephenson[1] | Martin A. Collins[2] | Simeon L. Hill[2] | William D. K. Reid[1]

[1]School of Natural and Environmental Sciences, Newcastle University, Newcastle upon Tyne, UK

[2]British Antarctic Survey, Natural Environment Research Council, Cambridge, UK

Correspondence
Huw W. James, School of Natural and Environmental Sciences, King's Road, Newcastle University, Newcastle upon Tyne, NE1 4LB, UK.
Email: h.james9@newcastle.ac.uk

Funding information
Natural Environment Research Council, Grant/Award Number: NE/S007431/1

Abstract

Monitoring reproductive traits in Southern Ocean species is challenging. Males in some channichthyids thicken the epithelium along their anal fins to aid nest construction. This study presents initial evidence that the only commercially harvested channichthyid, mackerel icefish (*Champsocephalus gunnari*), exhibits modifications to their anal fins, and that these features are ephemeral and possibly sexually dimorphic. The evidence presented may indicate nesting behaviour, although further work is necessary to validate this hypothesis. Confirming icefish nesting sites in the Scotia Sea could provide further support for the continued prohibition of bottom trawling.

KEYWORDS
Channichthyidae, fisheries management, icefish, life history, reproductive behaviour, South Georgia

Fish reproductive strategies are a central aspect for fisheries management and have often been used to justify conservation measures (Beets & Friedlander, 1999; Grüss et al., 2014; Morgan, 2008). In the Southern Ocean, several species of notothenioids, including icefish (Family Channichthyidae), utilise nesting and parental care as part of their reproductive strategy (La Mesa et al., 2021). This was exemplified by the vast *Neopagetopsis ionah* Nybelin 1947 nesting site discovered in the Weddell Sea (Purser et al., 2022). However, the prevalence of nesting behaviour across all channichthyid species remains uncertain and undertaking direct observations of their reproductive behaviour is a complex and costly process.

In captivity, mature male *Chionodraco hamatus* (Lönnberg 1905) developed a thickened epithelium on their anal fins (hereafter referred to as modified anal fins) during its nest construction phase (Ferrando et al., 2014). Histological examination and observations of nest building confirmed that the modified anal fins had a mechanical role during nest preparation and were used to 'sweep' the substrate in the nest area (Ferrando et al., 2014). In the same study, wild male *Chionodraco rastrospinosus* DeWitt 1980 captured in trawl surveys also exhibited modified anal fins. No direct observations of nest construction were recorded in *C. rastrospinosus*. However, as they are closely related to *C. hamatus* and share a similar habitat, it was assumed that *C. rastrospinosus* also constructs nests as part of its reproductive strategy (Ferrando et al., 2014). While not specifically studied, similar descriptions were noted for the anal fins of *Chaenocephalus aceratus* (Lönnberg 1906) (cited as E. Riginella pers. comm. in La Mesa et al. (2021)), which are known nesters (Detrich et al., 2005). Outside of channichthyids, temporary fin modifications associated with reproductive behaviour have been highlighted in other species and are often sexually dimorphic (Collette, 1965; La Mesa et al., 2021; Wiley & Collette, 1970). The thickening of the epithelium covering the pelvic and anal fins has also been noted as a substrate contact adaptation in benthic species and is not exclusively associated with reproduction (DeVries & Eastman, 1981; Eastman, 2024; Eastman & DeVries, 1985).

Champsocephalus gunnari Lönnberg 1905 have a widespread distribution in shelf waters across the Southern Ocean and have been commercially exploited in multiple regions, including around South

Georgia (Kock, 2005). Historically, *C. gunnari* were overfished, and their recovery was deemed to be ongoing at the end of the 20th century (Kock & Everson, 2003; Kock & Köster, 1990). Information regarding *C. gunnari's* reproductive strategy is currently ambiguous. Pelagic trawls conducted in the upper 200 m of the water column were reported to have captured *C. gunnari* eggs during the winter of 1987 (Koubbi et al., 1991). These eggs were identified by comparing the diameter of the captured eggs to those of mature oocytes, along with their seasonal occurrence in relation to the assumed spawning period (Duhamel, 1987a, 1987b). The data suggesting that *C. gunnari* eggs were pelagic (Koubbi et al., 1991), along with their high relative fecundity compared to other channichthyids, was interpreted as evidence of a broadcast spawning strategy (Militelli et al., 2015). In contrast, Everson et al. (2001) suggested that *C. gunnari* eggs were demersal as none were identified during extensive plankton sampling in South Georgia's fjords, which have been reported to contain spawning aggregations (Olsen, 1955). Furthermore, molecular studies confirmed that *C. gunnari* eggs were adhesive and cluster, suggesting that they were demersal in nature (cited as E. M. Fitzcharles, BAS, unpublished data in Young et al. (2015)). Compiling evidence to clarify the characteristics of *C. gunnari's* reproductive strategy is essential for sustainable management.

Here, we report preliminary evidence collected during a recent scientific survey that *C. gunnari* possess ephemeral modifications on their anal fins, which may suggest that this species incorporates nesting as part of its reproductive strategy. The small dataset provided tentative evidence that large mature males primarily exhibited modified anal fins. We recommend that future studies attempt to confirm the role of this feature along with its prevalence in all icefish species.

As part of the biennial demersal trawl survey, which is undertaken to estimate the biomass of *C. gunnari* and other demersal species, a total of 98 trawls were conducted during January and February 2025. The trawls took place on the continental shelves of South Georgia and Shag Rocks, using a 120-foot bottom trawl (FP120) (Belchier et al., 2015) aboard the fishing vessel FV *Sil*. From the 73 trawls which recorded *C. gunnari*, a total of 605 males and 762 females were sampled for full biological analysis. All fish used were sacrificed humanely in line with UK animal welfare laws. A subsample of 31 individual *C. gunnari* was collected and frozen whole (−20°C) from seven of the demersal trawls. These fish were selected randomly across both sexes and maturity stages and stratified by fish size. During the laboratory work, variation was noted in the anal fins of some of the individuals where the spines of the anal fin appeared to be covered in a thickened epithelium that was pale in colour (Figure 1a). Opportunistically, the anal fins of all 31 individuals underwent macroscopic inspection for the presence of any modifications as described in Ferrando et al. (2014). The maturity of the individuals was assessed using the five-point scale developed by Kock and Kellermann (1991).

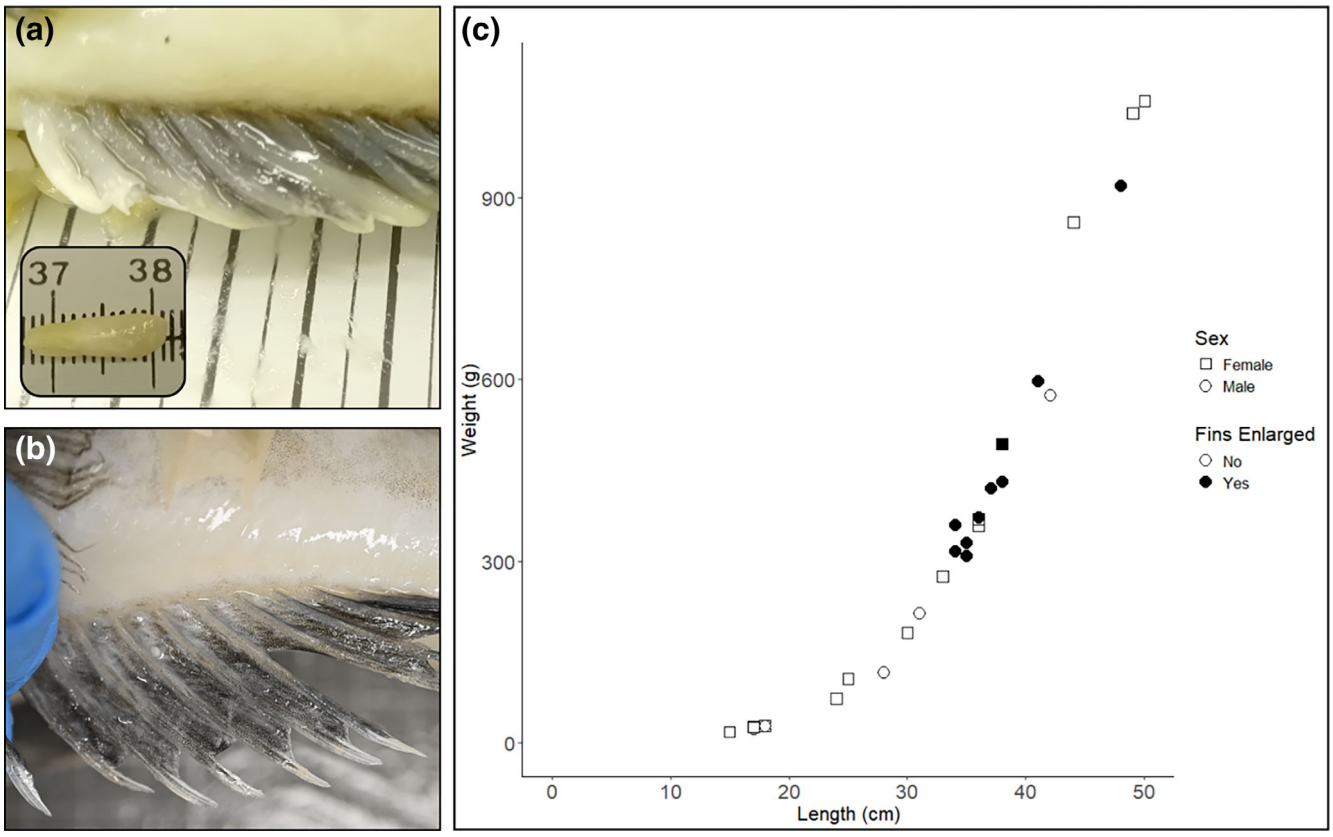

FIGURE 1 Photograph of a modified anal fin, normally observed in mature males as well as an inset image of the detached epithelium (a) Unmodified anal fin, generally observed in immature males and females (b). The length–weight relationship between male ($n = 17$, circles) and female ($n = 14$, squares) *Champsocephalus gunnari* with (black) and without (white) modified anal fins (c).

Of the subsample of 31 individuals, 17 were male and 14 were female (Table S1). All eight of the mature males (maturity stages 3 and 4) sampled exhibited modified anal fins, where the fin rays were covered by a thickened epithelium (Figure 1a,c). A single male at maturity stage 2 (developing/resting) and a single mature female (maturity Stage 3) also exhibited a thickened epithelium, partially covering the fin spines. All other females ($n = 13$) and immature males ($n = 8$) lacked a thickened epithelium on their anal fins (Figure 1b,c).

This study presents preliminary evidence of modified anal fins in the commercially important species *C. gunnari*. Some demersal notothenioids have been shown to thicken their fins as an adaptation associated with increased substrate contact (DeVries & Eastman, 1981; Eastman, 2024). Channichthyids, including *C. gunnari*, are benthopelagic and spend time on the seabed supported by their pelvic fins in a tripod position (Kock, 2005; Montgomery & Pankhurst, 1997). This behaviour could suggest that the modified fins may be a substrate contact specialism; however, they were absent in the majority of immature fish. Secondly, the thickened epithelia observed in *C. gunnari* were easily detached (as shown in video footage: Champsocephalus gunnari modified anal fins), indicating that these modifications were likely ephemeral and possibly seasonal in nature, similar to those described in nesting *C. hamatus* (Ferrando et al., 2014). Due to their apparent ephemeral nature, the features observed in *C. gunnari* were deemed unlikely to be associated with a demersal shift, which was hypothesised to require a more permanent morphological adaptation. Furthermore, although this study incorporates a small dataset, there was preliminary evidence to suggest that modified anal fins may be sexually dimorphic as they were mostly (but not exclusively) prevalent in large mature male *C. gunnari*. There is currently little evidence to suggest that increased demersal habitat occupation, associated with ontogenetic shifts (Frolkina, 2002), is sexually dimorphic in *C. gunnari*, and other large individuals (the majority of those >40 cm TL [Figure 1]) exhibited unmodified fins. This further supports the interpretation that the fin modifications are unlikely to result from ontogenetic demersal shifts alone. We therefore hypothesise that modified fins play a role in *C. gunnari's* reproduction and may indicate nesting behaviour in this species. While nest building in channichthyids has previously been interpreted as a male-only activity (Detrich et al., 2005; Ferrando et al., 2014; La Mesa et al., 2021), we observed a single female with similarly modified anal fins (Figure 1). The possibility that female *C. gunnari* participate in nest building is unexpected given the current understanding of sex-specific reproductive roles and, if occurring, would represent a unique behaviour among female channichthyids based on the available information.

To confirm the drivers of these physical adaptations, additional observational data are required. This could be achieved by incorporating similar methods to those adopted in Ferrando et al. (2014), where the reproductive behaviour of *C. gunnari* is monitored in aquaria. However, there has been limited success in channichthyid husbandry (Le François et al., 2017). Alternatively, in situ observations of wild *C. gunnari* could shed further light on their reproductive behaviour and whether there is a connection with modified anal fins. Due to these uncertainties, we recommend incorporating inspections for modified anal fins into the routine biological data collection methodology for *C. gunnari* where possible. As this feature has been observed in several members of the Channichthyidae (Ferrando et al., 2014; La Mesa et al., 2021), this additional data collection should be considered for all icefish species that are sampled, whether they are caught as target species or as bycatch.

Updating the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Scheme of International Scientific Observation sampling protocol incorporated for mackerel icefish fisheries could provide valuable data on fin modification. The examination of the anal fins for a thickened epithelium would have a low time cost and complement the standard biological sampling procedure. It would enable further investigation into the presence of fin modifications across size classes, cohorts and sexes of multiple icefish species and whether the feature is associated with mature individuals during the spawning season. The expanded data collection protocol could also be incorporated in other fisheries where channichthyids are captured as bycatch. However, additional requests need to be balanced with ongoing fisheries observer data collection requirements and should be collected on a voluntary basis.

If modified anal fins are confirmed as indicators of nesting in *C. gunnari* and/or other icefish species, the additional voluntary data we propose collecting could help identify the timing and location of nesting behaviour and guide efforts to capture in situ observations. Icefish nesting grounds have previously been proposed as the basis for spatial fisheries management measures, such as the establishment of marine protected areas (Purser et al., 2022). In conjunction, the findings from this study suggest that there are likely to be undiscovered icefish nesting sites across the Southern Ocean. Nesting sites are likely to be vulnerable to bottom trawling and their presence would offer additional support for continuing the explicit prohibitions of this fishing technique in the Scotia Sea. Identifying the locations of potentially vulnerable icefish nesting sites could inform fisheries management policy and contribute to more sustainable, resilient fisheries in the Southern Ocean. We therefore advocate further investigation into the drivers and prevalence of this phenomenon.

AUTHOR CONTRIBUTIONS

Huw W. James, Fabrice Stephenson, Martin A. Collins, Simeon L. Hill and William D. K. Reid conceptualised the study. Huw W. James and Martin A. Collins participated in the data collection and fieldwork. Huw W. James, Fabrice Stephenson and William D. K. Reid conducted the analyses and wrote the manuscript. Simeon L. Hill and Martin A. Collins edited the manuscript.

ACKNOWLEDGEMENTS

We would like to thank all the individuals who supported and participated in the 2025 demersal trawl survey. The authors would also like to thank the Natural Environment Research Council (NERC) and UK Research and Innovation (UKRI) for providing the PhD studentship (Grant number NE/S007431/1) via the IAPETUS2 Doctoral Training Partnership that funded this project.

FUNDING INFORMATION

Natural Environment Research Council (NERC) and UK Research and Innovation (UKRI) via the IAPETUS2 Doctoral Training Partnership PhD studentship (Grant number NE/S007431/1).

ORCID

Huw W. James https://orcid.org/0009-0007-3721-8790
Fabrice Stephenson https://orcid.org/0000-0002-9500-5204
Martin A. Collins https://orcid.org/0000-0001-7132-8650
Simeon L. Hill https://orcid.org/0000-0003-1441-8769
William D. K. Reid https://orcid.org/0000-0003-0190-0425

REFERENCES

Beets, J., & Friedlander, A. (1999). Evaluation of a conservation strategy: A spawning aggregation closure for red hind, *Epinephelus guttatus*, in the U.S. Virgin Islands. *Environmental Biology of Fishes*, *55*(1–2), 91–98. https://doi.org/10.1023/A:1007404421518

Belchier, M., Featherstone, L., & Oliver, J. (2015). Configuration of the FP-120 net used on UK groundfish surveys in CCAMLR Subarea 48.3 (South Georgia). *CCAMLR Working Group on Fish Stock Assessment WG-FSA-15/26*, *6*.

Collette, B. B. (1965). Systematic significance of breeding tubercles in fishes of the family Percidae. *Proceedings of the United States National Museum*, *117*(3518), 567–614. https://doi.org/10.5479/si.00963801.117-3518.567

Detrich, H. W., Jones, C. D., Kim, S., North, A. W., Thurber, A., & Vacchi, M. (2005). Nesting behavior of the icefish *Chaenocephalus aceratus* at Bouvetøya Island, Southern Ocean. *Polar Biology*, *28*(11), 828–832. https://doi.org/10.1007/s00300-005-0010-8

DeVries, A. L., & Eastman, J. T. (1981). Physiology and ecology of notothenioid fishes of the Ross Sea. *Journal of the Royal Society of New Zealand*, *11*(4), 329–340. https://doi.org/10.1080/03036758.1981.10423324

Duhamel, G. (1987a). *Ichtyofaune des secteurs indien occidental et atlantique oriental de l'océan Austral: Biogéographie, cycles biologiques et dynamique des populations* [Thèse de Doctorat d'État ès Sciences Naturelles]. Université Paris VI.

Duhamel, G. (1987b). Reproduction des Nototheniidae et Channichthyidae des îles Kerguelen. In *Colloque sur l'écologie marine des îles Subantarctiques et Antarctiques (Paris 25 Juin 1985)*, (Vol. 57, pp. 91–107). CNFRA.

Eastman, J. T. (2024). The axes of divergence for the evolutionary radiation of notothenioid fishes in Antarctica. *Diversity*, *16*(4), 214. https://doi.org/10.3390/d16040214

Eastman, J. T., & DeVries, A. L. (1985). Adaptations for cryopelagic life in the antarctic notothenioid fish *Pagothenia borchgrevinki*. *Polar Biology*, *4*(1), 45–52. https://doi.org/10.1007/BF00286816

Everson, I., North, A. W., Paul, A., Cooper, R., McWilliam, N. C., & Kock, H. K. (2001). Spawning locations of mackerel icefish at South Georgia. CCAMLR https://nora.nerc.ac.uk/id/eprint/18580/

Ferrando, S., Castellano, L., Gallus, L., Ghigliotti, L., Masini, M. A., Pisano, E., & Vacchi, M. (2014). A demonstration of nesting in two Antarctic icefish (genus *Chionodraco*) using a fin dimorphism analysis and ex situ videos. *PLoS One*, *9*(3), e90512. https://doi.org/10.1371/journal.pone.0090512

Frolkina, Z. (2002). Distribution of mackerel icefish (*Champsocephalus gunnari*) (Channichthyidae) around South Georgia at various stages of its life cycle. *CCAMLR Science: Journal of the Scientific Committee and the Commission for the Conservation of Antarctic Marine Living Resources*, *9*, 49–69.

Grüss, A., Kaplan, D. M., & Robinson, J. (2014). Evaluation of the effectiveness of marine reserves for transient spawning aggregations in data-limited situations. *ICES Journal of Marine Science*, *71*(3), 435–449. https://doi.org/10.1093/icesjms/fst028

Kock, K.-H. (2005). Antarctic icefishes (Channichthyidae): A unique family of fishes. A review, part I. *Polar Biology*, *28*(11), 862–895. https://doi.org/10.1007/s00300-005-0019-z

Kock, K.-H., & Everson, I. (2003). Shedding new light on the life cycle of mackerel icefish in the Southern Ocean. *Journal of Fish Biology*, *63*(1), 1–21. https://doi.org/10.1046/j.1095-8649.2003.00150.x

Kock, K.-H., & Kellermann, A. (1991). Reproduction in Antarctic notothenioid fish. *Antarctic Science*, *3*(2), 125–150. https://doi.org/10.1017/S0954102091000172

Kock, K.-H., & Köster, F.-W. (1990). The state of exploited fish stocks in the Atlantic sector of the Southern Ocean. In K. R. Kerry & G. Hempel (Eds.), *Antarctic ecosystems* (pp. 308–322). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-84074-6_35

Koubbi, P., Ibanez, F., & Duhamel, G. (1991). Environmental influences on spatio-temporal oceanic distribution of ichthyoplankton around the Kerguelen Islands (Southern Ocean). *Marine Ecology Progress Series*, *72*, 225–238. https://doi.org/10.3354/meps072225

La Mesa, M., Llompart, F., Riginella, E., & Eastman, J. T. (2021). Parental care and reproductive strategies in notothenioid fishes. *Fish and Fisheries*, *22*(2), 356–376. https://doi.org/10.1111/faf.12523

Le François, N. R., Sheehan, E., Desvignes, T., Belzile, C., Postlethwait, J. H., & Detrich, H. W. (2017). Characterization and husbandry of wild broodstock of the blackfin icefish *Chaenocephalus aceratus* (Lönnberg 1906) from the palmer archipelago (Southern Ocean) for breeding purposes. *Polar Biology*, *40*(12), 2499–2516. https://doi.org/10.1007/s00300-017-2161-9

Militelli, M. I., Macchi, G. J., & Rodrigues, K. A. (2015). Maturity and fecundity of *Champsocephalus gunnari*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* in South Georgia and shag Rocks Islands. *Polar Science*, *9*(2), 258–266. https://doi.org/10.1016/j.polar.2015.03.004

Montgomery, J., & Pankhurst, N. (1997). *Deep-Sea fishes: Sensory physiology*. Academic Press.

Morgan, M. J. (2008). Integrating reproductive biology into scientific advice for fisheries management. *Journal of Northwest Atlantic Fishery Science*, *41*, 37–51. https://doi.org/10.2960/J.v41.m615

Olsen, S. (1955). A contribution to the systematics and biology of channichthyid fishes from South Georgia. *New Magazine for Zoology*, *3*(1), 79–93.

Purser, A., Hehemann, L., Boehringer, L., Tippenhauer, S., Wege, M., Bornemann, H., Pineda-Metz, S. E. A., Flintrop, C. M., Koch, F., Hellmer, H. H., Burkhardt-Holm, P., Janout, M., Werner, E., Glemser, B., Balaguer, J., Rogge, A., Holtappels, M., & Wenzhoefer, F. (2022). A vast icefish breeding colony discovered in the Antarctic. *Current Biology*, *32*(4), 842–850.e4. https://doi.org/10.1016/j.cub.2021.12.022

Wiley, M. L., & Collette, B. B. (1970). Breeding tubercles and contact organs in fishes: Their occurrence, structure, and significance. *Bulletin of the American Museum of Natural History*, *143*, 147–215.

Young, E. F., Belchier, M., Hauser, L., Horsburgh, G. J., Meredith, M. P., Murphy, E. J., Pascoal, S., Rock, J., Tysklind, N., & Carvalho, G. R. (2015). Oceanography and life history predict contrasting genetic population structure in two Antarctic fish species. *Evolutionary Applications*, *8*(5), 486–509. https://doi.org/10.1111/eva.12259

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: James, H. W., Stephenson, F., Collins, M. A., Hill, S. L., & Reid, W. D. K. (2026). Modified fin morphology in mackerel icefish (*Champsocephalus gunnari*) may indicate nesting behaviour. *Journal of Fish Biology*, 1–4. https://doi.org/10.1111/jfb.70531